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CONTENTS

EMMETT REID DUNN, 1894–1956. By *K. P. Schmidt* 75
NEOTROPICAL FROG GENERA: *Prostherapis* VERSUS *Hyloxalus*, WITH REMARKS ON *Phyllobates*. By *Emmett Reid Dunn* 77
A NEW FROG OF THE GENUS *Rana* FROM MICHOACÁN, MEXICO. By *Richard G. Zweifel* 78
A NEW FOSSIL SALAMANDER OF THE GENUS *Siren* FROM THE EOCENE OF WYOMING. By *Coleman J. Goin and Walter Auffenberg* 83
THE EFFECTS OF TEMPERATURE ON SALIENTIAN BREEDING CALLS. By *Edward D. Bellis* 85
HERPETOFAUNAL DISPERSAL ROUTES THROUGH NORTHERN CENTRAL AMERICA. By *L. C. Stuart* 89
VARIATION AND NATURAL HISTORY OF *Plethodon jordani clemsonae* BRIMLEY. By *Albert Schwartz* 94
CORRELATING COSTAL GROOVES WITH TRUNK VERTEBRAE IN SALAMANDERS. By *Richard Highton* 107
A NEW SPECIES OF THE SNAKE GENUS *Sibon* FROM ECUADOR. By *James A. Peters* 109
THE TAXONOMIC STATUS OF SOME SOUTHWESTERN SKINKS OF THE MULTIVIRGATUS GROUP. By *John S. Mecham* 111
OBSERVATIONS ON THE BEHAVIOR OF BLIND AND BLINDED FISHES. By *Kenneth R. John* 123
A NOTE ON PRELIMINARY STAGES IN THE FOSSILIZATION OF FISHES. By *C. M. Breder, Jr.* 132
A NEW GENUS AND SPECIES OF ELOPID FISH (*Laminospondylus transversus*) FROM THE UPPER CRETACEOUS OF TEXAS. By *Victor G. Springer* 135

HERPETOLOGICAL NOTES

Objections to wholesale revision of type localities. By *Wilfred T. Neill* 140
The egg-laying habits of the salamander, *Ambystoma jeffersonianum*. By *Sherman Bleakney* 141
Additional records of the four-toed salamander, *Hemidactylium scutatum*, from Nova Scotia. By *Sherman Bleakney and Francis Cook* 142
Two erythristic *Plethodon cinereus* from Nova Scotia. By *Sherman Bleakney and Francis Cook* 143
A snapping turtle, *Chelydra serpentina serpentina*, containing eighty-three eggs. By *Sherman Bleakney* 143
A new size record for *Thamnophis marcianus* Baird and Girard. By *James L. Vial* 143
Another record of the atlantic leatherback, *Dermochelys c. coriacea*, nesting on the Florida coast. By *E. Ross Allen and Wilfred T. Neill* 143
Notes on the habitat of the scincoid lizard, *Brachymeles gracilis taylori* Brown. By *Angel C. Alcala and Alfredo Y. Reyes* 144
Hybridization in three species of spadefoot toads. By *Aaron O. Wasserman* 144
Behavior of the Cuban lizard, *Chamaeleolis chamaeleontides* (Duméril and Bibron) in captivity. By *Edward O. Wilson* 145
Further comments upon the western range of *Scaphiopus bombifrons*. By *Frederick A. Shannon* 145
The effect of salinity on the survival of larvae of *Bufo melanostictus* Schneider. By *Ronald Strahan* 146
Range extension of the salamander *Plethodon vandykei idahoensis*. By *Philip C. Dumas* 147
Use of copper wire in noosing lizards. By *Richard M. Eakin* 148
Recent collections of the California limbless lizard, *Anniella pulchra*. By *Joe Gorman* 148
Rana sylvatica Le Conte in Idaho. By *Philip C. Dumas* 150
Bat predation by the Cuban boa, *Epicrates angulifer Bibron*. By *Jerry D. Hardy, Jr.* 151
The eastern mud salamander, *Pseudotriton montanus montanus*: a new state record for New Jersey. By *Roger Conant* 152

ICHTHYOLOGICAL NOTES

Southern extension of the known range of the basking shark, *Cetorhinus maximus* (Gunnerus). By *F. G. Wood, Jr.* 153
Distributional and nomenclatorial notes on the suckers of the genus *Moxostoma*. By *C. Richard Robins and Edward C. Raney* 154
Records of some Gulf of Maine fishes. By *Leslie W. Scattergood and Gareth W. Coffin* 155
New and recent records for fishes in Chesapeake Bay. By *William H. Massmann* 156
Aggregational behavior in a freshwater sculpin. By *John Greenbank* 157
External morphology of an embryo whale shark, *Rhincodon typus* Smith. By *George K. Reid* 157
Mugil cephalus in Oklahoma and northern Texas. By *Carl D. Riggs* 158
The eastern Pacific species of *Callionymus*. By *James Böhlke and Daniel M. Cohen* 159
Night sharks, *Hypoprion*, from the Gulf of Mexico and the Straits of Florida. By *Stewart Springer and John R. Thompson* 160
Distributional records of fishes in western Canada. By *W. B. Scott* 160

REVIEWS AND COMMENTS 161

EDITORIAL NOTES AND NEWS 171

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T.
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. 85
. 89
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. 107
. 109
in
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. 141
nd
. 142
. 143
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. 148
. 148
. 150
. 151
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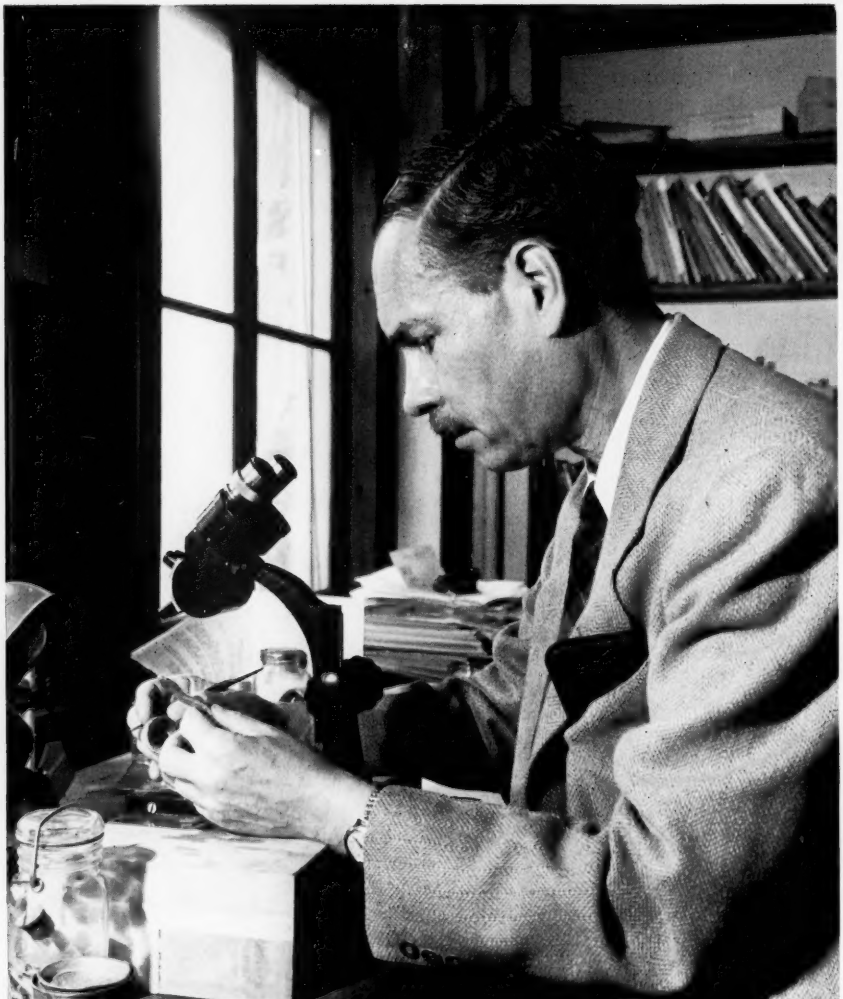

EMMETT REID DUNN
1894–1956

1957 No. 2 COPEIA July 15

Emmett Reid Dunn

1894-1956

EMMETT REID DUNN was a dedicated herpetologist who brought breadth of biological view as well as intensity of interest to his chosen field. He could thus take a major share with the colleagues of his own generation in the transformation of herpetology from its mainly descriptive past to its more interpretive and critical present. Even his first paper, in 1915, a study of the variation in a brood of water snakes, pointed in the direction of understanding the phenomena examined. In his subsequent career, on a basis of sound descriptive surveys of the families of salamanders, he became anatomist, ecologist, and zoogeographer, with original and incisive ideas in each field. Of all our group born in the decade of the nineties, he reminds me most of Edward Drinker Cope. E. R. D., or Dixie, or Hecho, as he was affectionately known to various intimates, had a mind intensely focussed on herpetology; a conversation with him might discuss amphibians and reptiles and questions about them for hours on end. From his first studies he became a field naturalist, and wide travels and the love of far places infused interest into his teaching and gave him prestige among students and colleagues.

As his description of a new peripatus from Panama is surprising departure from herpetology, so his East Indian expedition to collect the Komodo monitor for the American Museum stands out in a career of travel mainly in the Caribbean region. His earliest collecting trips were to the Appalachian Mountains, so rich in the salamanders he wished to study. As the plan for a systematic review of the *Salamanders of the family Plethodontidae* took shape, the problems posed by the sole tropical genus, *Oedipus* (in its broad sense), took him to the Mexican escarpment and to Costa Rica and Panama. He returned again and again to these latter countries, until he became the outstanding authority on the reptiles and amphibians of lower Central America. His long consecutive stay in Colombia falls naturally into the pattern of these interests. The results of his studies were embodied in papers on the composition of the herpetological fauna of Panama, critical reviews of various snake genera, and the useful summary of the Colombian amphibians and reptiles in *Caldasia* (Bogotá).

Dunn's first mentor in herpetology was Leonhard Stejneger at the National Museum. His second was Henry Sherring Pratt, his teacher at Haverford; and the influence of both was soon overshadowed by that of the commanding personality of Thomas Barbour, who was to be teacher, patron, and friend. The patroness of the first of Emmett Dunn's expeditions, to the North Carolina mountains, was Mary Cynthia Dickerson. I chanced to make my own first visit to the American Museum on the June day in 1916 when plans for that expedition were being discussed, and Miss Dickerson took us to lunch together in the old Mitla Restaurant. The congenial contact established on that day was to become a forty-year friendship, in which our two careers were sometimes crucially interwoven.

The young student's first teaching position out of college (B.S. 1915, M.A. 1916, at Haverford) was at Smith College, where he began as Assistant in Zoology, advancing by 1929 to Associate Professor. The curious course of this young naturalist's war service in 1917–1918 illustrates his complete dedication to his future interests. He was failed for a commission in the army, from officer's training school, entirely on the ground that his week-end pursuit of snakes and salamanders was conduct unbecoming to an officer candidate. Fortunately, the navy was free from such prejudice against natural history, and he received his commission as ensign, U.S.N., in 1917. On his return to Smith College, in addition to a stimulating friendship with the late H. M. Parshley, he was thrown into contact with two of the principal American students of salamanders, Dr. and Mrs. Harris Hawthorne Wilder. The remarkable and significant feature of lunglessness in the plethodontid salamanders had been pointed out by Professor Wilder in 1894, the year Emmett Dunn was born. Thus

the intellectual atmosphere at Smith was eminently favorable for salamander studies. Graduate work at Harvard next brought him into contact with Thomas Barbour at the Museum of Comparative Zoology. "TB", and the museum, financed much of his earlier field work, and it was natural that he should follow Barbour in the Caribbean field of interest, especially in Cuba and Panama.

On the faculty at Smith College Emmett Dunn found a congenial helpmate in Alta Merle Taylor. Together they made a hospitable and distinguished home when he transferred from Smith to Haverford; and together they made an effective team on all of the expeditions subsequent to their marriage in 1930. In 1934 Dixie Dunn succeeded Professor Pratt in the David Scull Professorship of Biology at Haverford. There, in the vicinity of Philadelphia, he naturally became Honorary Curator of Reptiles at the historically important Academy of Natural Sciences. Dixie and Merle Dunn interested themselves with some success in the attempt to bring order into the chaos into which the Cope collections had fallen through thirty years of inexcusable neglect. The Haverford teaching career was a distinguished one. The list of professional biologists and especially herpetologists who began their careers as Dunn's students is too long for this essay.

A John Simon Guggenheim Memorial Fellowship, in 1928, coming at a fortunately early stage in his career, had enabled him to study salamanders and caecilians at the museums in London, Paris, and Berlin. The absorbing interest in caecilians was shared, not without rivalry, with G. K. Noble, of the American Museum, and an agreement dividing the group, with the Old World forms for Dr. Noble and the New World ones for Dunn led to the completion of an important review of the American forms in 1942. Continuing interest in this group occupied much of his attention in later years, and the discovery, jointly with H. W. Parker, of astonishing features in the mode of reproduction of the viviparous forms became a crowning achievement, to be reported, after the long delay caused by Dixie's last illness, by Dr. Parker.

Among the herpetologists of his generation, his was the happiest literary gift. He practiced it as the second editor of Copeia (1924 to 1929). My greatest regret at his too early death is that his sensitivity to the excitement and romance of our profession could not be embodied in writings especially about his travels. He could have added distinguished volumes to the important class of "books of travel by naturalists." I well remember, when I was called upon to lecture on salamanders to a quite laboratory-minded student group at the University of Chicago, reading to them the opening words of his preface in his salamander volume:

> Much water has flowed under many bridges since the January of the year of our Lord one thousand nine hundred and thirteen, when a college Sophomore opened a letter and read a sentence, the results whereof are the following pages. It has been thirteen years since the eighteen-year-old boy read those few words and in those thirteen years for him the surf has whitened the shores of Caribbean islands; the slopes of the Balsams have been blue in the distance; hawks have soared a thousand feet below the naked peak of Sharp Rock; the iridescent wings of Morpho have fluttered through glades in the rain forest and in the mist of the cataract at Xico; from the mooring at Vera Cruz tall Orizaba has stood against the western sky; the low sun has shone on the ice of Ixtaccihuatl, most unforgettable of mountains; step after step, for him, far out at sea, Chirripo Grande, "nie von Menschenfuss betreten," has climbed aloft; and from shaken Irazu, while the ash cloud of the eruption rose above his head and floated a black pall beaten by the fierce wind, he has seen through a break in the clouds, far to the Southwards, the sheer and menacing shaft of rock which is Cerro de la Muerte.
>
> And in that letter and in that sentence there was no hint of high peaks or of distant places, of mountains seen and unclimbed and forever remembered, of the coughing of tigers by night in the black forest, there were only these words in that letter from Leonhard Stejneger "I would like to point out to you, however, that Herpetology offers fields more in need of investigation than the snakes, viz., the salamanders."
>
> Bald and prosaic words these, true though they were. Bald and prosaic has much of the work been, and, for those who venture further in what lies hereinafter, there is aridity and to spare. This is deplorable enough, but unavoidable, and while the written accounts of genera and of species unquestionably make dull reading, and were, it must be confessed, dull writing, yet the taking of specimens and the gathering of data and all that went therewith, and the remembrance thereof, has more than outweighed the dullness.

My hearers in the classroom almost held their breath. It was as if, for the first time for some, a curtain had been drawn aside to reveal the vast and grand landscape in which the naturalist moves and has his being. I have quoted at length because this preface tells something more about Emmett Reid Dunn than can the words of others.

The early interest of the young Dunn in natural history in general and in snakes and

salamanders in particular was a shock to the somewhat patrician Dunn and Reid families of Alexandria. They took it well, and must have been relieved to find the young naturalist welcomed and encouraged by Leonhard Stejneger at the National Museum just across the Potomac. The circumstance that his maternal uncle Legh Reid, the distinguished mathematician, taught at Haverford College, governed the choice of college. It proved a fortunate choice for both beginning and end of his career. Those careers are most fortunate in which nurture reenforces the drives of nature. Emmett Reid Dunn presents a happy example of education and inspiration combining with active interest into an intimate concordance of profession and personality. The life of scholarship brings distinguished rewards. The life of a teacher, naturalist, traveller and scholar, like that of Emmett Reid Dunn, seems to me to be the richest and most rewarding of all careers. Let us therefore write not only farewell, to our friend, but hail to our colleague's enrichment of our science. KARL P. SCHMIDT, CURATOR OF ZOOLOGY EMERITUS, CHICAGO NATURAL HISTORY MUSEUM.

Neotropical Frog Genera: *Prostherapis* versus *Hyloxalus*, with Remarks on *Phyllobates*

EMMETT REID DUNN[1]

PROSTHERAPIS Cope 1868; *P. inguinalis* Cope 1868; type specimen USNM 4349. Truando River, New Grenada, A. Schott. This specimen, long hidden by being labelled *Dendrobates tinctorius* (although it has teeth and toe-webs) was noted by me in 1946. I have no doubt that it is the actual type of the type species of the monotypic genus, thus confirming Parker's idea that Boulenger, Barbour, and Noble had erred in putting *inguinalis* close to *femoralis*.

The specimen is certainly congeneric with what I know from Panamá, Darien to the Azuero Peninsula, and have called *Hyloxalus* and with what I got high on both sides of the eastern Andes and down at Barranca Bermeja. I would think it conspecific with the Panamá forms and with those from Barranca Bermeja. I would now consider the two eastern Andean forms, *palmatus* Werner 1899 and *granuliventris* Boulenger 1919, as conspecific. I am getting less and less interested in geographical races.

Hyloxalus Jimenez de la Espada 1871, based on two so-called species from the same locality in eastern Ecuador, is a straight synonym of *Prostherapis*. *Hylixalus* Boulenger 1882 is a substitute name.

I consider that the presence of webs and fringes on the toes distinguishes *Prostherapis* from *Phyllobates* which hasn't got them. Ecologically *Prostherapis* is far more tied to the actual vicinity of water than is *Phyllobates*.

Phyllobates Bibron 1840–1841 (date uncertain); *P. bicolor* Bibron l.c.; type in Paris. "Cuba." In all probability Colombia, collected by Humboldt. Refer to Dunn, 1944 (Caldasia, 10: 491) and note that I now feel pretty sure that *Urotheca dumerilii* Bibron 1843 is the proper name for *Rhadinaea pachyura fulviceps* Cope 1886, and all *Rhadinaea* should be *Urotheca*.

The species has been taken since 1841 only in the eastern Andes of Colombia. I have seen about a dozen specimens.

Phyllobates melanorhinus Berthold 1845, Popayan. Type in Göttingen.

Phyllobates nicefori Noble 1923, Andes (the town in Antioquia). Type in the AMNH. This is different from all *other* "Phyllobates" in having no stripes, being much larger, and having skin venom so that it is used for arrow poison. I am as yet following convention in using *Phyllobates* for forms with teeth but without toe-webs.

Phyllobates brunneus (Cope) 1887, Matto Grosso, Brazil; types ANSP 11241-61. Refer to synonymy in Cochran, 1955. This is the

[1] Editor's note: Dr. Karl Schmidt, as Emmett Dunn's "Literary Executor," found this manuscript with an accompanying envelope addressed to your herpetological editor. Apparently the manuscript had either been prepared for publication or in answer to a letter I wrote Dr. Dunn in connection with a report I was preparing on Colombian amphibians. A request had been made for information on the status of the genera *Prostherapis* and *Hyloxalus*. This is probably the very last herpetological writing that Emmett R. Dunn did and it seems appropriate to publish it in the Dunn Memorial Number without alteration other than to supply a title and write out words he had abbreviated.

"*Phylobates subpunctatus*" of Ruthven from Santa Marta, and the *Dendrobates ranoides* of Boulenger from Villavicencio. The type of the latter is a *Phyllobates* with teeth, according to a letter from Parker, and there are no *Dendrobates* in the Villavo area according to the sylvan yellow fever men. It is also close to "*Dendrobates*" *talamancae* Cope 1875 from Costa Rica, which appears to get to Popayan and to El Centro. In both frogs the white dorso-lateral stripe is entirely above the dark lateral band, and runs from above the eye to the sacrum.

Phyllobates subpunctatus (Cope) 1899. The Bogotá species, like *Phyllobates latinasus* Cope 1863 from the Truando River, has a white stripe from above the eye to the groin, cutting diagonally through the black lateral band. In Panamá *Phyllobates* of this color have tadpoles with expanded lower lips (feeding on surface film), and males have swollen third fingers. At Andagoya I got the Canal Zone species, *flotator*. I have seen this type of coloration from many places; tadpoles are lacking and it would appear that only in the western Andes and in the Choco do the males have the swollen third finger. The name *boulengeri* Barbour is avialable for any race from southwestern Colombia.

Phyllobates pratti Boulenger 1899. Described from north of Medellin. *No* Colombian specimens are known except the types, nor is it in other South American countries. However *Phyllobates* with a light line from the groin halfway to the eye across the black lateral band are known from Costa Rica and from Panamá (fairly common in Panamá). This is the typical marking of *Prostherapis*.

Phyllobates femoralis (Boulenger 1883). East of the Andes. Big, yellow-striped, gaudy and very like a sympatric *Dendrobates pictus* D. and B 1841. Not much like any other *Phyllobates* but would key by color to *Phyllobates beatriciae* Barbour and Dunn 1921 (Costa Rica) and *Dendrobates auro-taenia* Boulenger 1913 (Choco). The latter has teeth and *is* a *Phyllobates*.

A New Frog of the Genus *Rana* from Michoacán, Mexico

RICHARD G. ZWEIFEL

THE southern part of the Mexican Plateau is known to be inhabited by two species of *Rana* related to the widespread species *Rana pipiens*. These frogs are *Rana montezumae* Baird 1854 and *Rana megapoda* Taylor 1942. There exists in Lake Pátzcuaro, Michoacán, a previously unreported frog of the *pipiens* group closely related to, but distinct from *montezumae* and *megapoda*. It is the purpose of this paper to describe this new form, and to compare it with the related neighboring forms.

Where specimens are referred to by number the following abbreviations are used: AMNH, American Museum of Natural History; UIMNH, University of Illinois Museum of Natural History; LSUMZ, Louisiana State University Museum of Zoology; USNM, United States National Museum. Measurements were made with a vernier caliper in the following ways: Body length from tip of snout to cloacal opening; head width opposite the tympana; tympanum diameter measured horizontally, including tympanic ring; tibia length from heel to fold of skin at knee; foot length from base of inner metatarsal tubercle to tip of longest toe.

The species is named for Emmett Reid Dunn, whose extensive studies on amphibians included naming the endemic salamander genus of Lake Pátzcuaro, *Bathysiredon*.

Rana dunni*, *sp. nov.

Plate I, B–D

TYPE.—Adult female, American Museum of Natural History A 58409, collected at the embarcadero, Lake Pátzcuaro, Michoacán, Mexico, by C. M. Bogert on November 15–16, 1955.

PARATYPES.—Sixteen specimens, AMNH A 58406-08, 58410-18, 59685 (skeleton), collected by C. M. Bogert at the same time and place as the type specimen, and 59237-40, collected at the type locality on August 14, 1956, by R. G. Zweifel.

DIAGNOSIS.—A species of the *pipiens* group of the genus *Rana* differing from the similar species *montezumae* and *megapoda* in the following ways: Maxillary teeth more numerous than

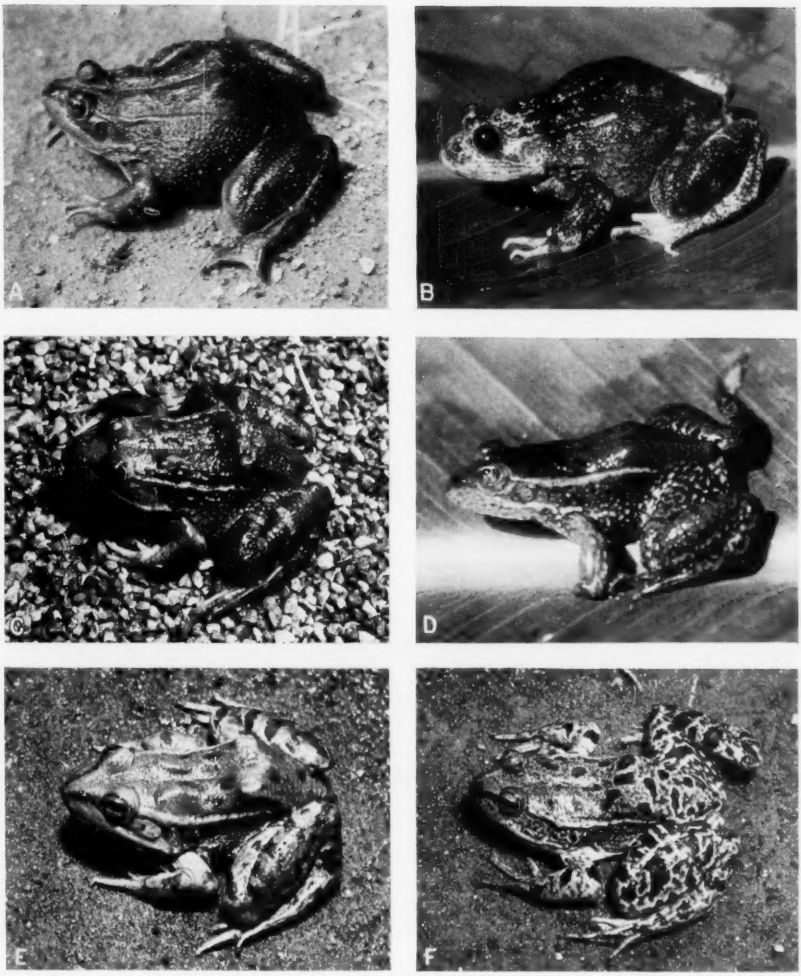

Plate I. A—*Rana montezumae*, Lagunilla de Ojuelos, México, adult. B—*Rana dunni*, type specimen, AMNH 58409. C—*Rana dunni*, paratype, AMNH 59240, subadult. D—*Rana dunni*, paratype, AMNH 58407, juvenile. E—*Rana megapoda*, AMNH 59230, juvenile. F—*Rana megapoda*, AMNH 59234, young adult.

in either of the other species; tympanum diameter averages smaller than *montezumae*, larger than *megapoda;* fingers one and two equal in length, or the first slightly longer (*megapoda* has the second finger longer); tibia length of adults shorter than in the other two species; coloration of adults distinctive; dorsal surface roughened by many small, rounded pustules (similar but smoother in *megapoda*, smoother with tendency toward longitudinal ridges in *montezumae*). These differences are discussed in more detail in the section on comparisons.

Description of type specimen.—Measurements (mm.): Snout-vent length, 97; head length, 30.9; head width, 34.0; tibia length, 38.9; foot length, 52.1; orbit diameter, 9.2; tympanum diameter, 7.5; interorbital distance, 4.2.

Head relatively wide and depressed, head width/snout-vent length equals 0.35; body chunky; limbs short and thick, tibia length/snout-vent length equals 0.39, foot length/snout-vent length equals 0.53; dorsal surfaces of body and limbs very pustulose; dorsolateral folds weak, terminating between groin and sacrum; an indistinct posttympanic fold; toes webbed to tip; toe tips small, rounded, without terminal expansion; toes in order of decreasing length, 4-3-5-2-1; fingers in order of decreasing length, 3-1-2-4; vomerine teeth in two groups between and slightly behind the internal nares; 77 maxillary teeth on one side; subarticular tubercles of feet very small, rounded; a small inner and no outer metatarsal tubercle; no distinct palmar tubercles; only one distinct subarticular tubercle on each finger.

Color and Pattern.—Preserved in alcohol, the type specimen bears a remarkable similarity in color to the half-tone illustration (Pl. I, B). The dorsal surfaces of the body and limbs (excluding the fingers and feet) are dark gray relieved by a very few indistinct and asymmetrical yellow-gray markings. The fingers are largely white; gray pigment extends along the fourth and fifth toes, whereas the webbing and rest of the foot are white. The head is yellowish-white with an irregular spotting of gray that covers perhaps half the area. The chin and chest region is largely gray, but the rest of the ventral surfaces, abdomen, legs and arms, are white.

Variation.—The largest specimen in the series is the type, which measures 97 mm. snout to vent. The only adult male measures 71 mm., the smallest individual 43 mm. Very probably the maximum size is somewhat greater than this small series would suggest.

Head width is relatively constant within the series. The HW/SV ratio averages 0.357 ± 0.003, range 0.34–0.37, n = 17. If ontogenetic change is present, it is not evident in these specimens. Foot length, too, is relatively constant: FL/SV mean = 0.550 ± 0.006, range 0.51–0.59. In relative tibia length, however, there is considerable ontogenetic change. For eight specimens more than 80 mm. snout-vent length, the mean TL/SV ratio is 0.386 (0.36–0.40). The nine specimens of less than 80 mm. length are longer-legged, average 0.414 and range 0.41–0.44. The first finger (measured after pressing the first and second fingers parallel to each other) is slightly longer than the second in nine instances and approximately equal to it in eight. Variation in tympanum diameter is shown in Figure 2. There are too few specimens to show whether sexual dimorphism in ear size is present, but there is no striking difference between the sexes.

The number of maxillary teeth increases with the growth of the frog. Four specimens in the 55–65 mm. snout-vent length range have from 51 to 65 teeth on one side, mean 57.7. Nine specimens ranging in size from 85–97 mm. have an average of 79.8 teeth, range 69–89.

The single adult male has external vocal sacs behind the angle of the jaw, in the position characteristic of frogs of the *pipiens* group.

Four adult females are very similar in pattern to the type specimen, two others have extensive irregular light markings on the back, and two have more dark pigment than the type, especially on the head. As seen in Kodachrome transparencies, the appearance of the adults in life was not much different from that in preservative (see description of type specimen). The light markings of the head, body and front feet have a yellow tint, while the light pigment of the hind feet is white. The dark pigment is dark gray in life. The smaller specimens show considerable variation in pattern. Four have several light spots four to five millimeters in diameter on the back and conspicuous light crossbands on the tibia and femur, while three of the smaller individuals show a peppering of light spots one to two millimeters in diameter over the back and legs. In life, the small frogs

that I examined (s-v length 47–64 mm.) were green, very light when captured at night, but much darker when examined in the daylight. Even in light phase, the spotting and banding was conspicuously lighter than the ground color. The small individual pictured in Plate I, D differed from others not only in possessing dark spots on the back, but also in having the dorsolateral folds colored differently from the rest of the dorsum. In life, the folds and the side of face were yellow-green, the ground color dark green. The lightheaded pattern seen in some adults is not evident in the smaller specimens. This difference, together with the light spots of most juveniles, makes their appearance somewhat different from that of the adults.

Comparison of *Rana dunni*, *Rana montezumae*, and *Rana megapoda*

Size.—Taylor (1942: 312) records a specimen of *megapoda* with a snout-vent length of 152 mm. This species is, then, the largest of the three considered. Taylor mentions a specimen of *montezumae* 116 mm. in length. The largest *montezumae* measured by me is the same size, but such large individuals are only infrequently encountered in collections. The vast majority of specimens are less than 100 mm. in length. The series of *dunni* is too small to allow a definite statement as to maximum size reached. The largest individual is 97 mm.; probably the species is similar to *montezumae* in size range.

Proportions.—Head width in *montezumae* and *dunni* is very similar. The average head width/snout-vent length ratio for 25 *montezumae* is 0.359 ± 0.003, range 0.34–0.39. The figures for 17 *dunni* are 0.357 ± 0.003 (0.34–0.37). In contrast to these two forms, *megapoda* has a relatively wider head as was noted by Taylor (1942: 313). The mean ratio for 25 *megapoda* is 0.382 ± 0.003, range 0.36–0.43.

One of the characters given as differentiating *megapoda* from *montezumae* (Taylor, 1942) was the supposed larger foot size of *megapoda*. However, a comparison of these forms by means of the foot length/snout-vent length ratio does not bear out the supposed difference. The figures for the three species are as follows: *dunni*, 0.550 ± 0.006 (0.51–0.59), n = 17; *montezumae*, 0.555 ± 0.005 (0.52–0.60), n = 25; *megapoda*, 0.555 ± 0.006 (0.53–0.61), n = 25.

Ontogenetic, specific, and probably geographic differences are present in tibia length. The following figures for tibia length/snout-vent length apply to specimens greater than 80 mm. in length: *dunni*, 0.386 (0.36–0.40), n = 8; *montezumae*, 0.451 (0.42–0.48), n = 8; *megapoda*, 0.458 (0.43–0.49), n = 14. The legs of the larger specimens of *dunni* are thus conspicuously shorter than those of the other two samples. For specimens less than 80 mm. in length, the following averages and ranges were computed: *dunni*, 0.414 (0.41–0.44), n = 9; *montezumae*, 0.453 (0.38–0.48), n = 9; *megapoda*, 0.441 (0.41–0.46), n = 11. Excluded from these statistics are the figures for 24 individuals of the smaller size group from the Distrito Federal. The mean for this group is 0.407, range 0.36–0.47.

These statistics for relative tibia length suggest the need for further investigation, when enough specimens of both adults and young available from several regions. The young individuals from the Distrito Federal seem to be shorter-legged than young *montezumae* from other localities. Unfortunately, I have not had the opportunity to see if large adults from Distrito Federal are similarly short-legged. Ontogenetic change from relatively long-legged juveniles to short-legged adults is evident in *dunni*, but no change of comparable magnitude is seen in the sample of *megapoda*.

I have not computed ratios with regard to tympanum diameter, but present the data in the form of scatter diagrams (Figs. 1 and 2). It is seen that adults of *montezumae* have distinctly larger tympana than individuals of

Fig. 1. Relative tympanum diameter in *Rana montezumae* (circles) and *Rana megapoda* (triangles). Closed symbols indicate males, open symbols females.

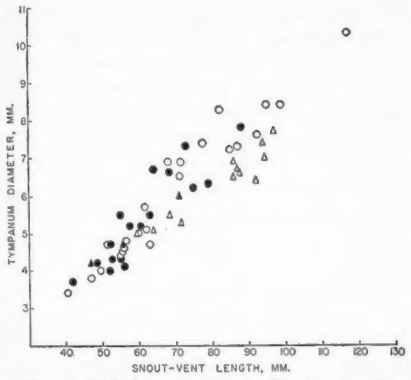

Fig. 2. Relative tympanum diameter in *Rana montezumae* (circles) and *Rana dunni* (triangles). Closed symbols indicate males, open symbols females.

megapoda of similar size. This difference was noted by Taylor (1942: 313). The tympanum size of *dunni* falls between that of *montesumae* and *megapoda*, the range overlapping the ranges of the other two species to a slight extent.

One of the differences between *megapoda* and *montezumae* lies in the relative lengths of the first and second fingers (Taylor, 1942: 313). I find the second finger longer than the first in all 24 specimens of *megapoda*, while in only one of 44 specimens of *montezumae* is the second longer; the first is longer in 24 instances, and the two are approximately equal in length in 19. With respect to finger length, *dunni* resembles *montezumae:* nine individuals have the first finger longer, and eight have the first and second fingers equal in length. The differences in finger length are slight, but consistent.

Tooth Count.—Wide variation at a given body size and considerable ontogenetic change tend to obscure differences in numbers of maxillary teeth among the three species, but average differences nevertheless are present. The following statistics (mean, range, number of counts) are for individuals in the 55–65 mm. snout to vent size range: *dunni*, 57.7 (51–65), n = 4; *megapoda*, 55.0 (50–61), n = 4; *montezumae*, 44.5 (42–51), n = 8. In this body size range, *dunni* and *megapoda* do not appear to differ, at least as far as can be told with the small samples. The counts for *montezumae*, however, are conspicuously lower. For the size group 80–100 mm. in snout to vent length, the following figures were obtained: *dunni*, 79.8 (69–89), n = 9; *megapoda*, 67.6 (61–75), n = 8; *montezumae*, 61.6 (52–74), n = 7. The differences between *montezumae* and *dunni* are greater here than in the smaller size group, and differences also become evident between *megapoda* and *dunni*.

Pustulosity of Skin.—*Rana dunni* is a conspicuously pustulose frog. Close examination reveals the skin of the dorsal surfaces to be roughened by numerous small, rounded pustules. These pustules are frequently emphasized by the presence of lighter pigment. *Rana megapoda* usually appears smoother than *dunni*, though the pustules are similar in shape. In contrast to *megapoda* and *dunni*, the pustules of *montezumae* are in many instances arranged into short, longitudinal rows, approaching the condition seen in *Rana pipiens* where there are usually numerous short folds between the dorsolateral folds.

Color and Pattern.—Young individuals of *montezumae* have a pattern of dark spots, frequently with a light outline, on a lighter background. The tibia and femur are marked with dark crossbars. Large individuals tend to have less conspicuous spotting and barring (Pl. I, A). Paul Rüthling noted that young specimens of *montezumae* collected near Guadalupe, Distrito Federal, were bright green in life (field notes in AMNH). The pattern of *megapoda* is similar to that of *montezumae*, but usually there is a reticulation between the spots on the back and legs that is not seen in *montezumae* (Pl. I, F, see also Taylor, 1942, pl. 28). Young individuals of *megapoda* that I collected at Lake Chapala were dark green dorsally with lighter green dorsolateral folds. The distinction in color between the folds and the back is lost as the animals grow. Young *Rana dunni* usually have light spots and bars on a dark background, and thus present a pattern essentially the reverse of that seen in the other two species. The combination of dark gray body with varying amounts of light yellow on the head and body appears to be unique in adult *dunni*, not approached by *montezumae* or *megapoda*.

In dark phase, the entire ventral region of *megapoda* is covered with a reticulum of dark gray or black on yellowish-white. In light phase, the reticulum is usually still evident on the anterior and ventral surfaces of the femora. Such a pattern on the entire venter is never

present in *montezumae*, where a general darkening without definite pattern may take place in highly melanistic individuals. Rarely a suggestion of a reticulum is present on the anterior part of the thigh. In light phase, the ventral surfaces of *dunni* are white and virtually immaculate. In dark phase, the chin and chest region becomes clouded with gray, but there is no definite pattern developed.

Adults of *dunni* have a dark eye, with little guanistic pigment, whereas juveniles have such pigment in conspicuous amounts. Both adults and juveniles of *megapoda* and *montezumae* have much guanistic pigmented in the eye, as compared to adults of *dunni*.

Specific vs. Subspecific Status for *Rana dunni*

Were it not for the extensive geographic overlap between *Rana megapoda* and *Rana montezumae*, it would seem reasonable to regard the three forms as races of a single polytypic species. In some respects (finger length, body size, head width), *dunni* is more similar to *montezumae*, and in others (number of maxillary teeth, character of pustules) there is closer resemblance to *megapoda*. Tympanum diameter of *dunni* is intermediate between *megapoda* and *montezuma*, while color pattern is unique in *dunni*. It is not possible to say that *dunni* is clearly closer to one than to the other species. Perhaps additional collections of frogs of this group will demonstrate additional instances of overlap, or even intergradation. It is entirely possible that *dunni* has developed in isolation in the Pátzcuaro basin, and is nowhere in contact with the other two species, each of which is present in two or more drainage systems.

Ecological Notes on *Rana dunni*

Lake Pátzcuaro lies at an elevation of about 7100 feet near the southern edge of the Mexican Plateau. The lake is at present in an isolated drainage basin with no outlet to the ocean, but possibly was within the drainage of the Río Lerma before being cut off by volcanic activity. The frogs were collected about the margin of the lake, most often in vegetation-choked water six to 18 inches deep. None was seen out of the water. The mating call of *dunni* is a slow, deep trill very reminiscent of the call of the spadefoot, *Scaphiopus hammondi*. When Mr. C. M. Bogert visited Pátzcuaro in November, 1955 and January, 1956, a strong chorus of *dunni* continued throughout the night. The frogs were calling when I collected at Pátzcuaro on the evening of August 14, 1956, but seemingly with reduced intensity. Mr. Bogert was informed by Tarascan Indians that this call was heard throughout the year. There were several gravid females among the frogs collected in November. Where the frogs were calling in January, the water temperature was 14°C, air 9.5°C.

Near Morelia, Michoacán, on August 13, 1956, I heard frog calls very similar to that of *dunni*, but was unable to collect specimens. At Chapala on August 15, where *megapoda* was collected, a call of the same sort was heard. *Rana montezumae* is also known to occur at Chapala, so the call heard cannot definitely be attributed to *megapoda*. Possibly all three species have similar calls.

The stomach of one specimen of *dunni* was filled with aquatic snails, identified by Dr. William K. Emerson as belonging to the genus *Physa*.

Geographic Distribution

In the following paragraphs, specimens examined are cited by museum number.

Rana dunni.—The only known locality is the embarcadero, Pátzcuaro, Lake Pátzcuaro, Michoacán (AMNH 58406-18, 59237-40, 59685).

Rana megapoda.—Jalisco: Guadalajara (AM NH 2954-67); 10 mi. N Chapala (AMNH 59230); Lake Chapala at Chapala (AMNH 59231-35); La Palma, Lake Chapala (Taylor, 1942: 310); Guanajuato: 13.8 mi. S Valle de

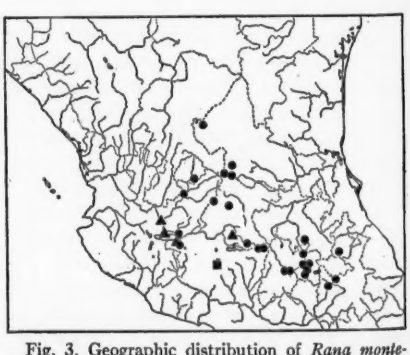

Fig. 3. Geographic distribution of *Rana montezumae* (dots), *Rana megapoda* (triangles), and *Rana dunni* (square).

Santiago (UIMNH 8182-86). The latter record constitutes the first record for this species outside of the state of Jalisco.

Rana montezumae.—In addition to the specimens listed below, which I have examined, Smith and Taylor (1948: 99) give a number of localities for this species. Most of these have been plotted in Figure 3. Distrito Federal: México (AMNH 1289); vicinity of Guadalupe (AMNH 12216-27, 13366-78). Guanajuato: Guanajuato (USMN 9891, 12684, 26155); Santa Rosa (USMN 47206). Jalisco: Teocaltiche (UIMNH 32308). Mexico: Lagunilla de Ojuelos, 5 mi. W Toluca (AMNH 55265-66). Michoacán: Tupátaro (USMN 10239 [3 specimens], 10243 [3 specimens], 10251, 10253-55, 10258); Sahuayo (USMN 113735); 5 mi. NW Maravatio (UIMNH 32304-05). Puebla: Chignahuapan (USMN 21454-59). San Luis Potosí: Arriaga (LSUMZ 2520-38, 2554-55); Bledos (LSUMZ 2549-50, 4275-77, 4285); 21 km. W Illesca (LSUMZ 2317); Laguna de las Rusias (LSUMZ 5654); Presa Gonzales Santos, 10 mi. SW San Luis Potosi (LSUMZ 4303-06); Presa Prudentia (LSUMZ 5668); Presa San Jose, 4 mi. SW San Luis Potosi (LSUMZ 4307-10); Sierra San Miguel, 7500 ft. (LSUMZ 4973).

Acknowledgments

For the loan of specimens used in this study, I am thankful to the following persons: Dr. Doris M. Cochran, United States National Museum; Drs. George Lowery and Richard T. Gregg, Louisiana State University; Dr. Hobart M. Smith, University of Illinois. Mr. C. M. Bogert and Mr. Samuel B. McDowell read and helpfully criticized the manuscript. Mrs. Frances W. Zweifel prepared Figures 1–3.

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A New Fossil Salamander of the Genus *Siren* from the Eocene of Wyoming

Coleman J. Goin and Walter Auffenberg

We have recently located three specimens of a fossil salamander of the genus *Siren* in the collections of Yale University. This discovery makes two important contributions to our knowledge of the Sirenidae. Until the present time the earliest known sirenid was *Siren hesterna* from the Lower Miocene of Florida. The new find indicates that the family was present in the Eocene and extends the range to Wyoming, far outside the present known distribution of the family.

These three specimens seem to represent a species heretofore unknown and we propose for it the name

Siren dunni, sp. nov.

Type.—Yale Peabody Museum 3873, a dorsal vertebra, collected by O. C. Marsh, Aug. 13–14, 1873.

Horizon and Locality.—Middle Eocene, Bridgerian, *Orohippus* Faunal Zone, Cottonwood White Layer; Henry's Fork, Bridger Basin, Sweetwater County, Wyoming.

Diagnosis.—A small *Siren* with the neural arch standing high above the centrum and with the zygapophysial ridge nearly straight as seen from the side. From the Recent species it differs in having the zygapophysial ridges more concave as seen from above and in the nearly straight horizontal position of the zygapophysial ridges as seen from the side. From *S. hesterna* of the Miocene of Florida it differs in the reduced angle between the aliform processes and in having a better developed floor between the aliform processes. From *S. simpsoni* of the Pliocene of Florida it differs in that the dorsal wing of the transverse process originates near the posterior margin of the centrum and swings up gradually to meet the zygapophysial ridge at an angle of about 40° whereas in *simpsoni* the dorsal wing originates well forward of the posterior margin of the centrum and rises

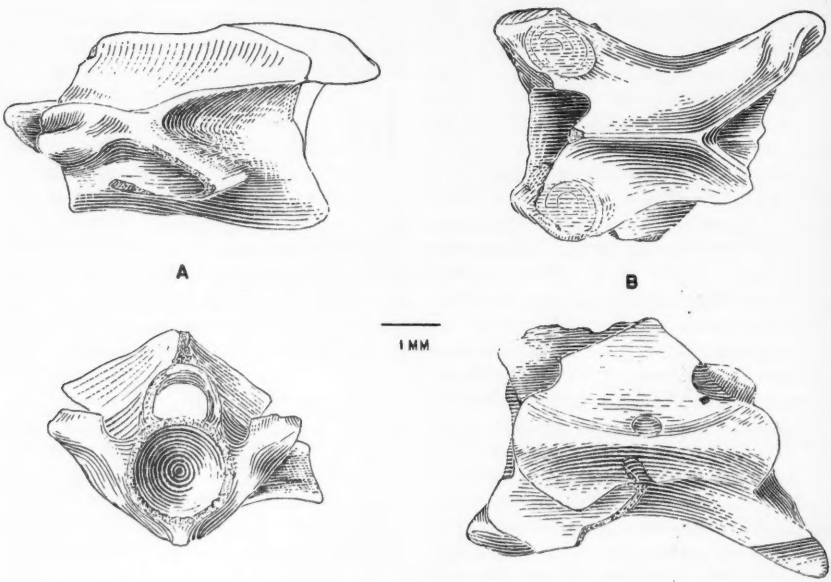

Fig. 1. Type specimen of *Siren dunni*, Yale Peabody Mus. No. 3873. A. Lateral view, left side. B. Dorsal view. C. Anterior view. D. Ventral view.

abruptly, meeting the zygapophysial ridge at an angle of about 60°.

DESCRIPTION OF TYPE.—Measurements in mm. (each measurement is also given in thousandths of the length of the centrum, in parentheses following the measurement): length of centrum along midventral line, 4.6. Width of vertebra at narrowest point of zygapophysial ridges, 2.8 (.609). Height of vertebra from lower margin of centrum to a line drawn between facets of postzygapophyses, 2.2 (.478). Distance from tips of prezygapophyses to tips of postzygapophyses, 6.6 (1.435). Angle between aliform processes, about 65°. Width of anterior glenoid cavity, 1.6 (.348); height of anterior glenoid cavity, 1.3 (.283). Width of neural canal, 1.0 (.217); height of neural canal, 0.9 (.196). Angle of posterior edge of transverse process with axis of centrum indeterminate.

Centrum longer than high; anterior glenoid cavity oval, wider than high, but somewhat eroded; posterior glenoid cavity definitely ovate and higher than wide. Centrum provided with an elevated, ridge-like, medium ventral keel, on either side of which is found a relatively large, subcentral foramen. Margin of ventral keel as seen from side nearly straight.

Total length of neural arch greater than length of centrum and its width at the narrowest portion of the zygapophysial ridges slightly greater than width of centrum. Neural canal stirrup-shaped both anteriorly and posteriorly; no median ridge on the floor of the neural canal.

Articulating surfaces of prezygapophyses broken on the left and eroded on the right, ovate in shape, longer than wide, directed more anteriorly than laterally. Articulating surfaces of postzygapophyses broken on the left, on the right ovate. Zygapophysial ridges well developed, markedly concave as seen from above. As seen from the side the zygapophysial ridge is nearly straight but it is slightly depressed where the dorsal portion of the transverse process meets the zygapophysial ridge.

Aliform processes well developed, vertical in position, somewhat rectangular as seen from the side but the left one broken and the right one somewhat eroded. As seen from above they form an anteriorly pointing V. Floor between aliform processes eroded so that its full extent is not discernible but it extends at least ⅔ of the distance to the posterior margins of the processes.

Neural spine well developed but its dorsal margin eroded.

Transverse processes well developed and composed of two plate-like portions, of which the ventral is larger than the dorsal. The ventral portion is a wing-like structure extending from close to the anterior margin of the side of the centrum for about ⅓ of the length of the centrum. Its tip is broken so that its transverse extent is not determinable. The dorsal portion is a flat plate extending from the zygapophysial ridge, somewhat behind the posterior margin of the prezygapophysis, ventrally and posteriorly to the posterior margin of the ventral portion to which it is fused. What is left of the posterior margin of the transverse process forms a concave curve. Laterally a foramen is present in the angle between the dorsal and ventral portions of the transverse process and another lies somewhat ventral and posterior to the angle between the dorsal portion of the transverse process and the zygapophysial ridge.

VARIATION.—In addition to the type, two other vertebrae (Yale Peabody Museum 3874 and 3875) are referred to this species. The first is from Dry Creek, Bridger Basin, Sweetwater County, Wyoming, collected by Lamothe and Chew, and the other is from the same locality as the type, collected by O. C. Marsh, Sept. 15, 1871. Although somewhat broken, they do tell us a little about variation. In both of these specimens the angle between the aliform processes is about the same as in the type but in one the processes stand higher, perhaps because they are less eroded. In both of them the floor between the aliform processes is more extensive than in the type but even here the posterior margin of the floor is eroded so that its maximum development cannot be determined. In one specimen the zygapophysial ridges as seen from the side are slightly sinuous rather than nearly straight as in the type. The other is like the type. The lower plate of the transverse process is relatively longer than in the type and extends for nearly the entire length of the centrum. In other characters than can be determined these specimens are essentially the same as the type. The centra are 3.7 and 4.6 mm in length and the greatest diameters of the posterior glenoid cavities are 1.4 and 1.6 mm.

We wish to thank Dr. Joseph T. Gregory for the privilege of borrowing and reporting on these specimens.

DEPARTMENT OF BIOLOGY, UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA.

The Effects of Temperature on Salientian Breeding Calls

EDWARD D. BELLIS

DURING the summer of 1952 and the spring of 1953 a study was made of the effects of temperature on the breeding calls of some Oklahoma salientians. An attempt was made to determine the relationship of air and water temperature to the number of calls produced in a given time interval (frequency of call) and to the lengths of the individual calls. All of the data were taken in the field in order to obtain results which would reflect the unhampered expression of the animals at the breeding sites.

Four species were studied: *Pseudacris nigrita triseriata* Wied, *Pseudacris clarki* Baird, *Pseudacris streckeri* Wright and Wright, and *Bufo terrestris charlesmithi* Bragg. All of the work was done in Oklahoma, the majority of it in Cleveland County.

METHODS

The data on frequency were taken in the following manner. The calls produced by an individual over a ten second period were counted. Eight such counts were made for each individual calling at a particular temperature. Timing was done with a stopwatch. The mean number of calls produced per ten seconds was calculated for the set of eight. This mean is plotted against temperature in the figures that follow. Hereafter a "set" will refer to a group of eight counts in all cases.

Length of call was determined by starting the stopwatch when a single call began and stopping it at the end of this single call. Eight call lengths were timed for an individual over a very short period of time. Again the mean was calculated

for the set of eight and plotted against temperature.

An attempt was made to time as many individuals as possible and, so far as is known, no more than one set was taken for one individual at a particular temperature.

Many of the data were procured with considerable difficulty, particularly those for *B. t. charlesmithi* and *P. streckeri*. These forms were usually represented by a paucity of individuals at the breeding ponds and frequently several minutes elapsed between stopping and starting of choruses. Imitation of these two species sometimes resulted in the commencement of calling. Although there is no reason to believe that the presence of the investigator had any effect on either the frequency or length of call, care was taken in approaching the chorus and illumination was kept at a minimum.

Both air and water temperatures were taken. In order to assure both speed and accuracy in the recording of temperatures, two standard centigrade thermometers were set up, the bulb of one placed just above the water surface and the bulb of the other just below. Maintenance of these in a permanent position throughout the period of timing in a particular area resulted in quick and reliable readings without undue effort. Thermometers were set up in what was considered to be an average calling situation, that is, an area which approximated the calling sites with respect to vegetation, water depth, and distance from the pond edge. While this method gave only an approximation of the actual temperature of the animal, it is probably the best that could be done under field conditions.

A small percentage of the data was taken from recordings made by Dr. A. N. Bragg at the calling sites. These were recorded on a device known commercially as the "Sound Scriber".

Results

Pseudacris n. triseriata

One hundred and fifty-eight sets of frequency counts were taken for this species. The mean number of calls produced per ten seconds is plotted against water temperature in figure 1. A highly significant positive correlation exists between calling frequency and temperature as

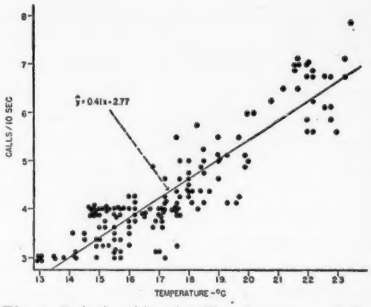

Fig. 1. Relationship of calling frequency of *P. n. triseriata* and water temperature.

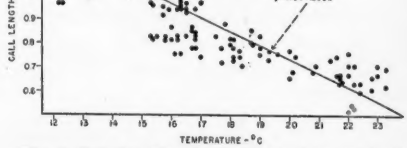

Fig. 2. Relationship of call length of *P. n. triseriata* and water temperature.

determined through use of the F test for regression. The relationship does not deviate significantly from a straight line at these temperatures. The frequency of call at this temperature range may be calculated through use of the formula $y = 0.41x - 2.77$ where y is an estimate of the number of calls given per ten seconds and x the water temperature in degrees centigrade.

When calling, this species is usually immersed in water to throat level, with only the head exposed to the air. It is for this reason that water temperature was plotted rather than air temperature. Air temperature, however, must not be disregarded as a factor affecting calling frequency. In order to test this, frequency of call was plotted against air temperature, but only at points where the corresponding water temperatures lay between 15.3 and 16.2° C. A slight increase in frequency was correlated with higher air temperature in this manner.

The means for 154 sets of length timings are plotted against water temperature in figure 2. There is a highly significant negative correlation

between call length and water temperature for this species at these temperatures.

As in the case where frequency of call was considered, air temperature must not be disregarded. Consequently, length of call was plotted against air temperature at points where the corresponding water temperatures lay between 15.3 and 16.2° C. A slight decrease in call length was associated with increase in air temperature.

The relationship between the total call time per ten seconds and the water temperature is shown in figure 3. Each point represents the product of a mean of a set of frequency counts and a mean of a set of eight length timings, both means having been calculated from data taken at the same temperature. It is apparent that the total call time remains constant at this temperature range, the increase in frequency being compensated for by the shortening of the calls.

Pseudacris clarki

This species calls from the same relative air-water position as the closely related *P. n. triseriata*, therefore water temperatures were used in the plotting of figure 4. A highly significant positive correlation between frequency of call and water temperature exists. This relationship shows no significant deviation from a straight line at these temperatures. An approximation of the frequency of call at this temperature range may be obtained through use of the formula $y = 1.55x - 13.24$ where y is an estimate of the number of calls produced per ten seconds and x the water temperature in degrees centigrade.

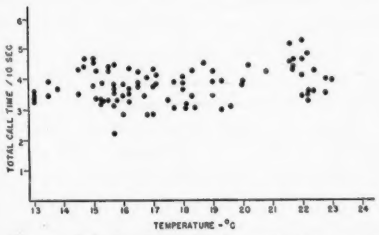

Fig. 3. Relationship of total call time per ten seconds of *P. n. triseriata* and water temperature.

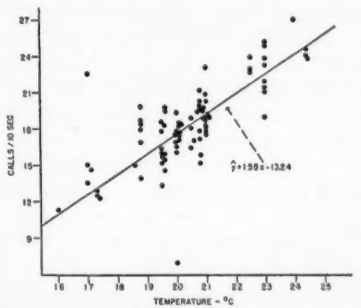

Fig. 4. Relationship of calling frequency of *P. clarki* and water temperature.

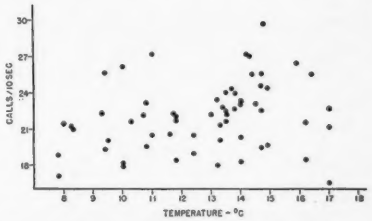

Fig. 5. Relationship of calling frequency of *P. streckeri* and air temperature.

Pseudacris streckeri

There is no reason to believe that water temperature appreciably affects the frequency of call of *P. streckeri* since this species characteristically calls from land positions at the pond margin.

The mean frequency of call for 60 sets is plotted against air temperature in figure 5. Evaluation by means of the F test for regression shows no significant relationship between the variables. The extreme scattering is probably the result of great variability in frog temperatures at the study area at any one time. Thus the thermometer could have been an inadequate indicator of the temperature of the frog in question and this discrepancy would result in the large differences in the mean frequency of call at the recorded temperature.

Bufo t. charlesmithi

The mean length of call for 46 sets is plotted against air temperature in figure 6. Since this species calls from land positions at the pond margin, water temperature was not considered. There exists a highly significant negative correlation between call length and temperature. Again the plotted means show a wide scattering which could very well be due to large

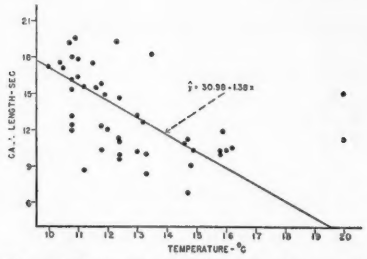

Fig. 6. Relationship of call length of *B. t. charlesmithi* and air temperature.

differences between actual frog temperatures and thermometer readings.

The call length of *B. t. charlesmithi* was quite variable within sets. Eight calls from an individual, timed over a period of a few minutes, frequently showed great variations in length. The mean difference in call length between the shortest and longest calls of a set was 6.6 seconds. The maximum difference was 15.5 seconds and the minimum 1.7 seconds.

Discussion

The fact that the frequency of call increased at higher temperatures is not surprising in light of many studies on rates of biological processes at varying temperatures. Many supporting examples might be chosen, but this discussion will be restricted to work done by previous investigators of salientian calls. Harper (1937) found that the frequency of call of *Pseudacris ornata* increased at higher temperatures. Conversely, Harper (1939) could find no correlation between temperature and frequency of call of *Hyla ocularis*, but he timed only a few individuals. Bragg (1940) discovered that extremely low air temperatures were correlated with slower, lower pitched calls in *Bufo cognatus*. Bragg (1942) suggested that higher air or water temperatures might be responsible for a greater calling frequency in *Pseudacris streckeri* and the same author (1943) noted the call of *Pseudacris clarki* to be a slow grinding note at low temperatures, quite different from the rapidly produced, higher pitched note at 12° C. or above. Employing a stop watch in the field, Bragg (1948, 1950) made further studies on salientians. His data show a definite trend toward higher calling frequencies at higher temperatures. Additional support comes from Jackson (1952) who found the frequency of call of *Acris crepitans* to increase with temperature. His data suggest that the relationship is not a straight line one since the frequency of call increased at a much faster rate above approximately 85° F. (29.4° C.), but he added that this cannot be definitely supported, due to an insufficient number of samples at higher temperatures.

Since the frequency data for *P. n. triseriata* and *P. clarki* extend over the same temperature range, they may be compared with respect to Q_{10} values. The Q_{10} for *P. N. triseriata* is 2.21 at the 15–25° C. range and that for *P. clarki* is 2.55. Characteristically, Q_{10} values lie between 2 and 3 for most biological processes.

Aside from temperature, many more variables must be considered as factors influencing the frequency and length of call in salientians. Variations in humidity were not measured in this study but their effects should not be underestimated, particularly in cases where animals are at a distance from freely evaporating water surfaces. Wind movements increase the evaporation rate and thereby produce variations in body temperature, unmeasured as far as this study is concerned. A possible correction could be made by measuring the temperature of the animal directly by means of thermocouples, but this method does not seem feasable, since the apparatus would in all probability alter the psychological state of the animal.

Other variables are even more difficult to analyze, such as the hormone level and the proximity of potential mates.

Bragg (1950) observed that there exists "a considerable influence of one individual on the other" in the induction of vocalization. Observations by the writer support this statement. Apparently, a primitive social structure is an attribute of the choruses, with the result that certain leaders call forth the breeding calls of their colleagues by their own breeding calls. This phenomenon is especially pronounced in *Hyla v. versicolor*, *Pseudacris streckeri*, and *Microhyla carolinensis olivacea*; but it has been observed to some extent in several species. The leader effect has been studied by Goin (1949) who found that choruses of *Hyla crucifer bartramiana* consist of trios, the members of which incite the calls of their fellows with a trill which is unlike the regular breeding call.

Many of the data in this study were collected near highways. Thus, an opportunity was presented for the observation of the effects of traffic noises on breeding congresses. A passing motor vehicle frequently initiated the commencement of call of *P. streckeri*. The causative factor is unknown. Conversely, a cessation of calling in *P. n. triseriata* was associated with traffic on several occasions, but only late in the breeding season, when the size of the congregation was small. Perhaps the animals could hear the automobile or truck noises only when their own sound production was at a minimum. Twice in one evening a passing airplane was associated with complete cessation of choruses of *P. n. triseriata*. This happened at the height of the breeding season, at a time when automobile noises had no apparent effect on the performers. One by one, the individuals again took up the song, after the sound of the airplane had faded in the distance.

Summary

The breeding calls of four species of salientians were timed with a stop watch under natural conditions in an attempt to determine the effects of temperature on the frequency and length of call.

A highly significant positive correlation between frequency and water temperature was found in *Pseudacris n. triseriata* and *Pseudacris clarki*. No significant correlation between frequency and air temperature was found in *Pseudacris streckeri*, probably due to discrepancies between thermometer readings and frog temperatures.

A highly significant negative correlation between call length and temperature was found in *P. n. triseriata* and *Bufo t. charlesmithi*.

The total call time per ten seconds for *P. n. triseriata* was essentially constant between 13 and 23° C.

Among other variables which might influence the frequency and length of call are humidity, wind, hormone level, and social factors.

Acknowledgments

The author wishes to thank Dr. A. N. Bragg of the University of Oklahoma for his inspiration and advice during the course of the work. The helpful criticisms of Dr. Joseph Gall, Dr. David Merrell, and Dr. Grover Stephens all of the University of Minnesota, are greatly appreciated.

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Zoology Department, University of Minnesota, Minneapolis, Minnesota.

Herpetofaunal Dispersal Routes Through Northern Central America

L. C. Stuart

In 1931 E. R. Dunn presented his classic analysis of the herpetofauna of the Americas and demonstrated that the origins and subsequent dispersals of New World amphibians and reptiles could be interpreted on the basis of conservative geological principles in accord

with Matthewsian concepts. His arrangement indicated a very old South American element, somewhat younger Middle American and southeastern United States element, and a modern circumpolar, northern element. It has been through the dispersal of representatives of these several elements in various directions that extant herpetofaunal assemblages have been formed. To my knowledge Bogert and Oliver (1945) were the first to analyze one such assemblage on the basis of Dunn's classification of major elements and the dispersals of the same. There can be no question that if further similar studies on herpetofaunal assemblages composed of several of these elements are to be undertaken, the nature of movements and the routes utilized by their representatives through the Central American isthmus must be given primary consideration.

Unfortunately these matters have been noted and discussed in only the vaguest terms (G. G. Simpson, 1950). It is time, therefore, that cognizance be taken of the fact that Central America has, since the first opportunity for faunal movements, presented a complex environment as a whole and an intricate pattern of habitat-types in particular. Organisms, and terrestrial vertebrates especially, do not appear to have wandered at random through the Central American isthmus. Rather, the majority appear to have followed specific, oftentenuous and even somewhat discontinuous dispersal routes in their movements. The following attempt to analyze some of the herpetofaunal routes through northern Central America, in the light of the scantiness of our knowledge of the systematics and distribution of many groups, may appear premature. Nevertheless, a preliminary discussion may be useful to systematists and geographers dealing with various other groups of animals, especially at generic and subgeneric levels, within the region under discussion.

By northern Central America I mean that region, both upland and lowland, lying between the Isthmus of Tehuantepec and southern Nicaragua. This block, often referred to as Nuclear Central America, has remained, with the exception of certain portions of its lowlands, as a continuous land area throughout most of the Cenozoic. There is evidence, very scant to be sure, to indicate that Nuclear Central America, up to the Pliocene, consisted of lowlands surrounding a moderately elevated upland core, subjected as a whole to a warm, moist climate and supporting a cover of forests broken with savannas. In late Miocene or early Pliocene two events occurred that radically altered the environment of the region. First, there was initiated a reduction in temperature, which reached a series of extremes in the Pleistocene, and second, the area entered into a period of uplift, which, in places, has amounted to 2500 meters, and which was accompanied by violent volcanic activity. This brought about further temperature reductions in the uplands and through the production of mountain barriers modified local wind systems and initiated the development of the extant climatic pattern. Throughout the Pleistocene, of course, the region was subjected to climatic fluctuations varying from cold and moist (glacial stages) to warm and dry (interglacial stages). Maximum temperature depression possibly amounted to about 5° C.

In its present form northern Central America may be viewed as an upland mass lying upon an only slightly-elevated platform of lowlands. The central core of the entire area may be taken as the high mountain blocks of central Guatemala, which stretch across the land mass at elevations of 1500 to 3600 meters to within 45 kilometers of the Pacific and 85 kilometers of the Caribbean. Both to the north and to the south of this central core the uplands decrease in elevation and lose their highland character in the Tehuantepec region and southern Nicaragua respectively.

Temperature throughout the region is largely a function of altitude and varies from roughly 26° C. (mean annual) to possibly 10° C. on the highest plateaus. As a generalization the Caribbean (windward) side is humid, the Pacific (leeward) versant relatively dry, while the upland surface between presents an intermediate condition. Exceptions to this general rule are, however, numerous. The outer end of the Yucatan Peninsula and the rain-shadow valleys of Guatemala and Honduras (e.g., respectively Motagua and Comayagua), though in the Caribbean drainage, are xeric, while along the Pacific from middle Chiapas to central Guatemala humid conditions prevail. Furthermore, at high elevations on the uplands heavy mists coupled with reduced temperatures frequently produce extremely moist environments, some of which have strong seasonal fluctuations in this respect.

In accord with the climatic pattern, the Caribbean lowlands in general support a cover of broadleaf forest that varies from semi-deciduous to true selva. The windward slopes of the uplands, in particular, sustain very humid forests that culminate in the "cloud forest" lying between 1500 and 2500 meters. Cloud forest is also present along the Pacific where suitable elevations occur, as in southwestern Guatemala. The Caribbean lowland forests are frequently broken by local patches of savanna such as the chain that extends from Veracruz through northern Guatemala, or those of the Mosquito Coast. The vegetation of the Pacific lowlands runs pretty largely to tree-savanna with gallery forest, though moist forest is indicated in the Chiapas—Guatemala section previously mentioned. The uplands above 2500 meters (exclusive of their slopes) support a cold steppe-land broken with humid forests of pine, fir and cypress. Between 1500 and 2500 meters on the uplands of the interior the pine-oak forest represents the dominant cover-type. At lower elevations in the interior region steppe or savanna, either with or without trees, scrub-forest and brushland are the commonest vegetation-types. In rain-shadow valleys and basins both on the lowlands and the uplands a cover of steppe, savanna or thorn-forest is the rule. The last also obtains in outer Yucatan.

I suggest that these extant environmental conditions which were initiated at the onset of late Miocene uplift, have persisted since the Pliocene. Pleistocene climatic fluctuations unquestionably raised and lowered climatic and vegetational belts and brought about extensions and recessions in the broad ecotone between the humid forest and dry-land cover-types. Nevertheless, the very configuration of the terrain of the region indicates that the general pattern of extant environments is one of considerable age.

For the purpose of orientation Dunn's arrangement of the American herpetofauna may be outlined as follows:

1. Holarctic Element: a modern, northern circumpolar group.
2. Old Northern Element: the New World analogues of groups now found on the southern fringes of Palearctica and Paleotropica (Schmidt, 1954).
   Here included are
   a. Older Element: southeastern United States and Central American group.
   b. Younger Element: southwestern United States and Mexican Plateau group.
3. South American Element: a very old group with analogues in the Australian Region and Ethiopian Subregion.

In 1950 I suggested the addition of a fourth element to this scheme, an Autochthonous Middle American group comprising a few families represented also in the South American Element, but which underwent separate evolution in Middle America while other representatives of the same were differentiating in South America. To these Schmidt (1943) had previously applied the term "hanging relicts," and, as will be brought out, these had a history similar to that of the Old Northern Element.

The ancestors of these elements may be viewed as having dispersed in waves from north to south. The first wave passed through Middle America and entered South America prior to the mid-Eocene disjunction of the two continental areas in southern Central America. Isolated until at least the mid-Miocene in the southern continent, these ancestral types evolved into the modern South American Element, while a few stragglers that had remained behind in Middle America differentiated, during the same time span, into the Autochthonous Middle American Element. A second wave, the ancestors of the Old Northerners, entered Middle America after the mid-Eocene and were unable, therefore, to continue on into South America. It appears that these, together with the ancestors of the Autochthonous Middle American Element, underwent evolution side by side in three separate centers: (1) northern Central America where developed *Bolitoglossa*, *Plectrohyla*, *Corythophanes*, *Coniophanes*, *Dermatemys* and *Staurotypus* to mention but a few, (2) the Mexican Plateau, the center of origin of such genera as *Pseudoeurycea*, *Sceloporus*, *Barisia*, and *Thamnophis*, and (3) southern Central America, the center for possibly *Agalychnis*, *Basiliscus*, *Ninia*, and *Leptophis* among others. Finally a third wave, the modern Holarctic Element, initiated a very recent southward movement, but to date has penetrated no further south than southern Mexico.

We are concerned herein with neither the Holarctic Element nor the northern Central American segment of the Old Northerners and Autochthonous Middle Americans. The former have failed to reach the region under discussion, while the latter developed within the region and appear to have simply differentiated locally through genetic drift operating in the presence of minor barriers. It is, rather, the Mexican segment of the Old Northern and Autochthonous Middle American Elements and the southern Central American segments of the same, together with the South American element that command our interest. It has been these groups that appear to have moved through Nuclear Central America along routes with specific habitat-types in accordance with their respective life requirements. In the final analysis the northward and southward movements of the several elements have depended in a large measure upon the ability of their individual representatives to breach the high mountain barrier of central Guatemala with its narrow annectant lowlands. A general route northward first became available to the southern elements (excepting, of course a few island-hoppers) possibly in the mid-Miocene when an interoceanic portal in southern Nicaragua finally closed. Aside from an open portal in the Tehuantepec region during a short period in the Pliocene, a route southward into Central America had always been available to the northern elements, yet these do not seem to have begun their southward migrations until the close of that period.

The dispersing groups appear to have moved along specific routes that may be outlined as follows:

Lowland Routes
  Humid Routes
    Forest Route
    Savanna Route
  Subhumid Route
Highland Routes
  Plateau Route
  Mountain-slope Route

Turning first to the Lowland Routes, the Humid subtype is generally distributed along the Caribbean side of central America southward to eastern Panama. It lies, for the most part, below 600 meters and presents a wet forest as a continuous habitat-type. A route of this nature occurs also along the Pacific in Chiapas and western and southern Guatemala, but it is so short that it appears to have had no role in north-south movements through northern Central America as a whole. The Forest Route has been utilized primarily by the South American and lower Central American Elements in their movements northward. It thus offers an interesting contrast to the Subhumid Lowland and Highland Routes, which will be shown to have been the main pathways southward for the Mexican group. Conspicuous southerners that have followed this route northward include *gollmeri*-like species of *Eleutherodactylus*, *Agalychnis* (in part), the *leucophyllata* group of *Hyla*, *Ameiva festiva*, *Xenodon*, *Dipsas* and arboreal *Bothrops*. Aside from *Eumeces sumichrasti*, which barely enters Honduras, none of the northerners appear to have utilized this route exclusively.

In contrast to the continuity of the forest, the Savanna Route on the humid lowlands is broken and occurs as isolated patches along the Caribbean versant from southern Veracruz to southern Nicaragua. These savannas are, for the most part, neither climatic nor very permanent but form, rather, a habitat-type of somewhat ephemeral existence that has expanded and contracted with climatic fluctuations or has appeared briefly following local catastrophies such as fire or innundation. On the basis of our present knowledge this route does not appear to have been particularly effective among either northerners or southerners. This, however, may not be fully understood, for savannas and their associated faunas have received but scant attention from biologists and even Beard (1953) in his account of the savannas of northern tropical America accorded them only inadquate treatment. The dispersal of northern groups like *Ameiva undulata* (secondarily dispersed), *Ctenosaura*, and *Masticophis*, has certainly been facilitated by this route southward along the Caribbean versant, while *Sceloporus teapensis* and *Coluber* appear to have utilized the savannas to have reached central Peten. Of the southern groups only *Dryadophis* and several *Anolis* of southern affinities assuredly followed this pathway northward.

It may be well to point out that though these Caribbean mesic lowlands extend continuously from Mexico to Panama, their associated

herpetofauna has not made full use of this habitat-type as a pathway southward. Many northern lowland elements, some of considerable age, have failed to penetrate beyond the region limited by the Yzabal Embayment of Guatemala and the Ulua Valley of Honduras. Outstanding examples are the turtles *Dermatemys*, *Staurotypus*, and *Claudius*, the lizard genera *Laemanctus* and *Sceloporus*, and *Ficimia* and *Adelphicos* among the snakes. The reasons for this phenomonon are yet to be discovered. They could be physical, e.g. an embayment of some duration in the region, or, perhaps, biological, such as Schmidt's suggestion (1943: 251) of want of dispersal pressure resulting from phyletic decline in some groups. In general southern elements, especially the South American forms do not show this sharp break in the northern limits. Genus after genus, rather, drops out at random towards the north in a series such as *Atelopus-Chironius-Dendrobates-Erythrolamprus* between Costa Rica and Honduras respectively.

In a previous paper I have presented a detailed account of the Subhumid Lowland Route (Stuart, 1954a), so that it need be reviewed only briefly here. This route consists of a chain of savannas and desert basins that begin at the Isthmus of Tehuantepec, breach the highlands of central Guatemala, expand over the relatively low uplands of southeastern Guatemala, Hondruas and Nicaragua and form a continuous pathway southward along the Pacific lowlands of Central America from middle Guatemala to eastern Panama. There they cross over to the Caribbean side to continue as the dry lands of northern South America (Dunn, 1940). This route has been utilized primarily by northern elements, which in most instances have not penetrated farther south than Costa Rica. Conspicuous representatives include parts of both the *siniferus* and *variabilis* groups of *Sceloporus*, *Enyaliosaurus*, *Cnemidophorus sacki*, and possibly *Conophis* in part. Southern elements that have followed this pathway northward include *Engystomops*, the *rubra* group of *Hyla* (*stauffer*i) and *Gymnophthalmus*.

The Highland Routes are not strictly highland, since the Mountain-slope Route may descend to as low as 600 meters. The Plateau Route, on the other hand, lies entirely above 1500 meters but is continuous only between the Tehuantepec region and southeastern Guatemala. At this latter point the general upland level drops to about 1000 meters elevation and higher levels through Honduras and Nicaragua occur only on disconnected mountain blocks. Nevertheless, as I have suggested in a previous study (1954b: 33), a slight reduction in temperature such as must have prevailed during the several glacial stages would have permitted some groups to utilize even these lower elevations as a montane pathway. The majority of the groups that have utilized this route show no marked preference for either the forest or grassland habitat-type (Stuart, 1951: 19–20), both of which are present. Emigrants from the north, which have passed along this route, are all essentially highland types dispersed from the Mexican Plateaus. Thus their crossing of the low, hot Isthmus of Tehuantepec was probably not effected until the Pleistocene and their only slight penetration into Central America lends further support to this suggestion. Northern types that have moved southward over the high plateaus of Chiapas and Guatemala include *Pseudoeurycea*, the *Hyla eximia* group, *Barisia*, the *formosus* group of *Sceloporus* and *Thamnophis cyrtopsis*. Only *Pseudoeurycea*, *Barisia* and *Sceloporus*, however, have penetrated beyond the continuous portions of the route in southeastern Guatemala. To my knowledge none of the southern elements has moved northward over this pathway.

The Mountain-slope Route is at best ill-defined, and both its nature and its fauna are but poorly understood. In the north it is confined to the slopes of the high plateaus on both the Caribbean and Pacific sides, but toward the south it appears to become badly confused with the higher mountain blocks rising above the plateau surface. In general it embraces elevations between about 600 and 3500 meters, though it may extend higher locally. It presents a variety of habitat-types that run the gamut from relatively dry oak and pine forests to the very wet cloud forest. It is, however, too early to associate any of the groups that have used this route with any very specific habitat-type. From the north *Chiropterotriton* appears to have utilized the Pacific slopes to reach Guatemala. *Xenosaurus*, also ranging only to Guatemala, and the *Tantilla schistosa* group, have made their ways southward along the

Caribbean slopes. *Pituophis* and *Abronia* have also reached only central Guatemala, but have moved along both versants. Migrants from the south may include *Agalychnis moreleti*, *Trimetopon*, the *Drymobius chloroticus* group, and the *nigrocinctus* group of *Micrurus*.

Some genera have, of course, utilized various combinations of these routes. *Ctenosaura*, *Masticophis* and *Crotalus* have, for example, moved southward through both the savannas of the Humid Lowland Route as well as through the Subhumid Lowland Route. The southerners *Leptodactylus* and *Constrictor* appear to have made use of the lowlands in general, while *Rana* has swept southward over lowlands and highlands alike.

It should be noted that these routes cut indiscriminately across biotic regions, be they life zones or biotic provinces. It has always seemed to me, as inferred by Dunn (1922), that the regional concept, which apparently strives to summarize faunal similarities and dissimilarities, has contributed very little to our understanding of the origins and subsequent dispersals of groups, especially at the generic level. It has proven useful, it is true, but because it is a static concept, it should be viewed as a starting point rather than an end insofar as broader systematic principles and problems are concerned.

Acknowledgments

In the preparation of the foregoing I have cribbed shamelessly from the knowledge of my colleagues at the University of Michigan, especially from Drs. Charles F. Walker and Norman E. Hartweg. To them I wish to acknowledge both my guilt and sincere thanks. Dr. Karl P. Schmidt has been kind enough to read my manuscript and to offer many pertinent suggestions, the majority of which have been incorporated herein.

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Department of Zoology, University of Michigan, Ann Arbor, Michigan.

Variation and Natural History of *Plethodon jordani clemsonae* Brimley

Albert Schwartz

Plethodon clemsonae was described by Brimley (1927: 73) from four specimens taken at Jocassee, Oconee County, South Carolina, one of them from " . . . near the lower falls of Whitewater." Apparently no more specimens were obtained until 1941, when Arnold B. Grobman and M. B. Mittleman collected two adults at the type locality. Of these individuals Bishop (1941: 20) stated that they "agree in all essential details with Brimley's description of the species and differ markedly from *P. metcalfi*." Later Grobman (1944:

293–4) expanded the use of the name *P. clemsonae* to include "the dark bellied populations of the Metcalfi Group (other than *shermani* and *jordani*) that occur in the Southern Blue Ridge Mountains south of the range of *metcalfi*. This arrangement allocates to *clemsonae* certain material formerly placed in *metcalfi* and topotypic *clemsonae*." Grobman stated further that "it is quite likely that *clemsonae*, as herein recognized, is polytypic." He thus distinguished between a high altitude black-bellied form and a low altitude brown-bellied form. The salamanders with black bellies have since been described as *Plethodon shermani malaventris* by Pope and Hairston (1948: 107). Later Hairston and Pope (1948) discussed geographic variation and speciation in the *Plethodon jordani* group; their map shows that the range of *clemsonae* abuts upon that of *melaventris*, the former inhabiting low elevations, the latter living generally at higher elevations but descending to 1200 feet. They regarded *P. clemsonae* as a subspecies of the red-legged *Plethodon shermani* which occurs to the northeast in the Nantahala and associated mountain ranges of North Carolina. With the discovery of intergrades in North Carolina between *P. jordani* and *P. metcalfi* at Hyatt Ridge, Great Smoky Mountains, and between *P. metcalfi* and *P. s. melaventris* in the Balsam Mountains, Hairston (1950) considered that the forms *jordani*, *metcalfi*, *melaventris*, *shermani*, *teyahalee*, *rabunensis*, and *clemsonae* were conspecific, and that they should be regarded as subspecies of *Plethodon jordani*. I concur with this treatment of *clemsonae* and present further evidence in support of this taxonomic relationship in the present paper.

There have been few specimens of *clemsonae* available to investigators, and the variation within the population as well as the geographic range has not been adequately defined. In the summer of 1953, J. C. Nicholls of Murphy, North Carolina, took over 30 specimens at Jocassee on two consecutive nights. Dennis R. Paulson and I visited the type locality and, using Nicholl's technique, secured two specimens on August 2, 1953 and later, accompanied by L. Neil Bell, 37 specimens on August 30, 1954. It seemed apparent that *clemsonae* was not so rare as has been previously thought. A period of study was therefore initiated that extended from August, 1953 to July, 1954. The objectives were to ascertain the amount and kind of variation and to gather information on life history, geographic distribution, and relationships of *clemsonae* with the adjacent member of the species, *P. j. melaventris*.

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Area of Occurrence and Climate

The village of Jocassee no longer exists. It was situated at the foot of the Blue Ridge Mountains in Oconee County. At present the Jocassee Valley is inhabited by summer vacationers and several permanent farmers who cultivate the valley floor where it is sufficiently broad. A girls' camp, tenanted only during the summer, is located on the northeast side of the

valley at the site of Jocassee. In many places the steep mountain slopes stand immediately behind the dwellings or reach the road itself. Of pertinence to later discussion of localities, it should be pointed out that at a distance of 3.2 miles northwest of Jocassee, at the confluence of Whitewater River and Thompson Creek, the road abruptly ascends the mountain side after crossing Thompson Creek at the Jocassee Gun Club. This unimproved road ascends steeply, and recrosses Thompson Creek twice in its ascent to the vicinity of the Lower Falls of Whitewater River. About one-half mile to the northeast of Jocassee, Whitewater River, after making an abrupt bend to the north, joins the Toxaway River, and the Keowee River is thus formed. The latter flows generally in a southeastern direction into the Piedmont; and later contributes to the Seneca River in southern Oconee County; ultimately its waters reach the Tugaloo and Savannah River system.

Immediately to the south of Jocassee the countryside is typically Piedmont. The red clay hills and rolling topography support plants more typical of the Piedmont than of the mountains. Much of the forest has been either removed or heavily cut and the land is extensively under cultivation, with cotton the principal crop. Jocassee might thus be said to lie directly upon the dividing line between the Piedmont and Blue Ridge Mountain physiographic provinces. The cutting of the original stands of timber and cultivation of the Piedmont have undoubtedly played an important part in restricting the occurrence of *clemsonae*.

The Jocassee Valley, approximately 1000 feet in elevation, is considered here as being montane in its affinities. The general aspect of the region reminds one strongly of higher elevations in the southern Blue Ridge Mountains. The valley is surrounded by steep hills and mountain slopes. Small streams, springs, and brooks are commonplace, and the deep, shaded ravines offer haven for *clemsonae* as well as the plant, shortia (*Shortia galacifolia*). The southwestern slopes of the valley are covered with a dense growth of rhododendron (*Rhododendron maximum*) and laurel (*Kalmia latifolia*). The profusion of these montane plants provides dense shade and abundant leaf litter. On the northeastern side of the valley and on the more exposed hilltops they are not so abundant, and the forest has a more open aspect with white pine (*Pinus strobus*) predominating. The shaded ravines also contain sourwood (*Oxydendron arboreum*), tulip tree, (*Liriodendron tulipifera*), red maple (*Acer rubrum*), beech (*Fagus grandiflora*), white holly (*Ilex opaca*), the fern *Polystichum acrostichoides*, and *Vincetoxicum suberosum* and the exposed slopes hornbeam (*Carpinus caroliniana*), dogwood (*Cornus florida*), chinquapin (*Castanea alnifolia*), and the fern *Polystichum acrostichoides*. While the ravines are very moist, well shaded, and with little ground cover other than shortia and leaf litter, the exposed slopes are dry, sunny, and support a moderate growth of grasses and shrubs. The sides of the ravines are often eroded and the bare earth is exposed, with the roots of trees acting as stabilizing agents. Logs are scarce in the ravines, and are but sparsely scattered throughout the more open pine forest on the exposed hill sides.

The region has a generally mild climate. There is no United States Weather Station at Jocassee, but a station for the recording of precipitation is located at Salem, Oconee County, about 7 miles to the southwest. Salem is within the Piedmont, and, although the weather conditions are somewhat similar at Salem and Jocassee, the precipitation and temperatures at the latter locality are undoubtedly somewhat influenced by its proximity to the mountain mass. On at least one occasion (August, 1953) heavy rain fell at Jocassee while Salem was completely dry. Thus precipitation at Salem does not necessarily reflect the precipitation at Jocassee, and this should be taken into account.

At Salem, within the period of study, 55.52 inches of rain were recorded. Very likely the amount in Jocassee Valley is several inches in excess of this figure. Maximum rainfall occurred in January (10.86 inches), while December was the next wettest month with 10.23 inches. Minimum rainfall was recorded for June (1.14 inches), with July slightly higher (1.53 inches). In general, the winter months have the most precipitation (very seldom as snow), while the summer is dry. Table I represents the precipitation recorded at Salem for the week preceding collecting at Jocassee for each month of the year, the number of salamanders taken, the general precipitation or ground moisture due to a rain at Jocassee, and the temperature recorded at the time of collecting. These

TABLE 1

COLLECTING AND CLIMATIC DATA FOR *Plethodon jordani clemsonae*

Date	Precipitation at Salem for preceding seven days (in inches)	Temperature at Jocassee (°C)	Precipitation at Jocassee	Number of salamanders
August 2, 1953	0	—	+	2
August 30, 1953	0	—	—	37
September 26, 1953	3.61	—	+	0
October 11, 1953	0	13	—	11
October 25, 1953	0	20	—	13
November 21, 1953	1.33	18	+	14
December 27, 1953	1.19	2	— (ice)	0
January 10, 1954	0	10	+	4
February 7, 1954	trace	10	—	1
February 22, 1954	3.08	9	+	7
March 13, 1954	1.10	15	+	16
April 19, 1954	.74	29	—	2
May 16, 1954	1.98	18	— (ground wet)	17
June 15, 1954	.73	26	— (ground wet)	7
July 16, 1954	.62	26	—	0

Jocassee temperatures represent diurnal as well as nocturnal temperatures. They suggest the temperatures at which *clemsonae* is above ground under logs, or foraging in the open.

The type locality of *clemsonae* was stated by Brimley as merely, "Jocassee". According to him (*op. cit.*: 74) the type specimen was collected by J. A. Berly of Clemson College on April 8, 1927; two paratypes were taken by Franklin Sherman on the same date at the same locality. In an effort to ascertain whence these three specimens came, I have questioned Nicholls and corresponded with Grobman. The latter states (*in litt.*) that "Sherman took Mittleman and myself to the area.... He took us to the camp near Jocassee ... and we walked up stream along the left bank of the Whitewater River.... We walked a good hour, I am sure, before we came to a place where Sherman said, 'This is about it'.... I think the way to locate the approximate type locality would be to start at the camp at Jocassee, walk along the left bank of the Whitewater River and collect in the vicinity of the first falls. The actual site would be somewhat inland from the River bank, on the slopes. We were not actually in sight of the River when we were at Sherman's type locality." The left bank herein referred to is the southwestern bank of the river. Nicholls on the other hand, recalls being taken by Sherman to a locality near the confluence of the Toxaway and Whitewater Rivers, and apparently on the shore of the former; Sherman indicated to him that this was the type locality. Thus we have two places, both of which Sherman indicated as being the locality whence the type specimen came. The original material was collected for use as bait for trout fishing, but proved ineffective and was accidently taken back alive in a bait can. Unable to identify the salamanders, Sherman sent them to Brimley, who described them as a new species.

A third paratype was recorded by Brimley (*op. cit.*: 74) from "Jocassee, South Carolina, ... near the lower falls of Whitewater". It was described by him (*loc. cit.*) as "similar to type but throat paler and no pigment dots on back". The assigning of this specimen to *clemsonae* is open to doubt. The locality is well within the Blue Ridge Mountains, and at a higher elevation (1500 feet) than Jocassee. Hairston and Pope (1948: 275, map) considered this specimen as *Plethodon j. malaventris* because of Brimley's description (which agrees with that of specimens of the more montane *melaventris*), the higher elevation, and the taking of a specimen of *P. j. melaventris* approximately one mile to the north of this locality at an elevation of 2000 feet. Although their assumption is probably correct, it will be shown below that *melaventris*-like individuals occur sparingly at Jocassee; consequently this specimen may indeed be assignable to *clemsonae*, and only further collecting at the Lower Falls will reveal the character of the population at that locality.

Hairston and Pope (*loc. cit.*: map) show seven triangles representing what were then all the known localities for *clemsonae*. Hairston has identified these localities for me as follows: (1) the type locality as defined by Brimley (open triangle) which has been shown to be dubious. (2) Jocassee, or, more exactly, the ravine on the southwest bank of Whitewater River opposite Camp Jocassee (three triangles together). (3) upstream and north of the Whitewater River. This site is about halfway between the bridge at Jocassee and the entrance to the Jocassee Gun Club, which is located where the road crosses Thompson Creek. (4) upstream from locality (3) and on the southwest side of the river. Hairston states (*in litt.*) that this site "should

be closer to (3) than shown on the map. It is across the river from some summer cottages and is reached by a swinging foot bridge." The mileage to this locality is 1.5 miles northeast of Jocassee by road. The swinging bridge is now in complete disrepair but the river is usually fordable by foot at this locality. (5) near the end of the logging trail about one mile from the chain blocking the road at the Jocassee Gun Club.

In the present paper "Jocassee" is used to indicate both the ravine referred to above in locality (2) and the hillside immediately above and adjacent to this ravine. Specimens have also been taken by myself and others at the following localities in the vicinity of Jocassee: 1.5, 1.9, and 2.0 mi. NW, east side of river; .9 and 1.4 mi. NW, west side of river; and 1.1 mi. by road N of Jocassee Gun Club, at Thompson Creek crossing. All these localities are at the lower elevations of the Jocassee Valley except the last. This locality is on the road to Lower Whitewater Falls, at an elevation of approximately 1200 feet. Further collecting at likely sites on this road above 1200 feet revealed no salamanders. I have also collected specimens at Hairston and Pope's locality (4); this locality is presumed to be close to some of the present localities on the northeast side of the river.

Kezer (*in litt.*) informed me that he has collected *clemsonae* at Hairston and Pope's locality (4) and Conant, Humphries, and Gordon have taken specimens at Jocassee in the ravine, on the path through the rhododendrons which parallels the river, and on the diagonal path leading up the hillside from the Jocassee Bridge.

The geographic distribution of *clemsonae* is thus the Jocassee Valley in Oconee County, South Carolina, at elevation between 1,000 and 1,200 feet. Persistent collecting at other localities in this same general region (*ie.*, Oconee and Pickens counties) has yielded no specimens of this salamander, even on warm rainy nights when the amphibian fauna was especially active. The specimen from the Lower Falls of Whitewater River, one of Brimley's paratypes, is here assumed to be referable to *P. j. melaventris*. Specimens of this latter salamander have been taken at the following localities near Jocassee in South Carolina and these records serve not only to clarify the range of *P. j. melaventris* in South Carolina, but also to indicate localities close to the range of *clemsonae*, at which *clemsonae* does not occur: *Pickens Co.* Rocky Bottom; 3.3 mi. N Rocky Bottom; 5 mi. N, thence 5 mi. NW Pickens; summit of Sassafras Mountain: Table Rock State Park. *Greenville Co.* Caesar's Head; Caesar's Head, 1.2 mi. S of North Carolina line on highway 276. *P. j. melaventris* is likewise well known from the North Carolina counties (Jackson, Transylvania) which border Oconee, Pickens, and Greenville counties. Specimens of *Plethodon jordani* from high elevations in Rabun County, Georgia (which borders Oconee County on the west) have been referred to the race *rabunensis*. So far as known, no specimens of *clemsonae* have been secured anywhere in Georgia, although collecting at lower elevations along the foot of the Blue Ridge in that state may reveal this salamander. The absence of *clemsonae* from other stations in Oconee County is puzzling. What appears to be suitable habitat to the east of Jocassee on South Carolina route 288 has been repeatedly searched, but neither *clemsonae* nor *P. j. melaventris* have been taken there.

The Jocassee Valley area supports a variety of other amphibians and a few reptiles. The following salamanders have been collected either in the montane brooks and springs of the region, beneath logs on the wooded hillsides, or on the road at night during wet weather: *Desmognathus ochrophaeus carolinensis*, *Desmognathus quadramaculatus*, *Desmognathus monticola monticola*, *Eurycea bislineata*, *Eurycea longicauda guttolineata*, *Pseudotriton ruber schencki*, *Gyrinophilus danielsi dunni*, *Plethodon glutinosus glutinosus*, and *Ambystoma maculatum*. *Aneides aeneus* occurs in rocky areas. The brooks in the ravines harbor *Rana catesbeiana* and *Rana pipiens*. *Rana clamitans melanota* occurs along stream margins and in the immediate vicinity of ponds. *Rana sylvatica sylvatica* (Quinby, 1954) and *Rana palustris* breed at Jocassee, as do also the toads *Bufo terrestris americanus* and *Bufo woodhousei fowleri*, and the treefrogs *Hyla crucifer crucifer* and *Hyla versicolor versicolor*. The only reptiles observed and/or collected were *Carphophis amoenus amoenus*, *Tantilla coronata* (*coronata* x *mitrifer*), *Heterodon platyrhinos*, *Storeria dekayi wrightorum*, and *Eumeces laticeps*. This assemblage of Piedmont and montane forms indicates the intermediate position of the Jocassee region.

The salamander most often encountered beneath logs and debris on the hillsides is *clemsonae*, while *P. g. glutinosus* ranks second. However, these two species were not found occupying the same niche.

Specimens of *clemsonae* have been collected both at night and during the day. J. C. Nicholls advocated collecting at night by flashlight; his series of about 30 specimens had been taken by this method. Originally it was the only method used, and visits to Jocassee in August and September, 1953, were made at night. The largest number of specimens taken (37) was collected by three persons in one evening using the flashlight technique. After no success at night in September, 1953 (in spite of extremely humid conditions and continuous rainfall), logs were turned during the day on the hillside above the ravine. This produced salamanders, but not in such great numbers as the nocturnal collecting in August, 1953. Due to low temperatures, winter night collecting yielded few or no salamanders. Daylight collecting on the same dates was more successful. The presence of the animals under logs during the winter suggests that they are active at that time, and that they forage in the open when weather conditions are suitable. Only in December, 1953, were salamanders absent under logs; this was apparently due to low temperatures (2°C). Ice was present even under logs. It seemed probable that, given a December day when weather conditions were less severe, salamanders would have been present. *P. j. clemsonae* is thus regarded as being active throughout the entire year, except on those winter days when the temperature is below 9°C and ice is present on the surface of the ground.

At night *clemsonae* can be seen on the walls of the ravine and on the exposed mud bank just above the spring at Jocassee. The large series of August 30, 1953 was taken between 8:00 and 10:00 PM and the salamanders were encountered either emerging from their burrows in the ravine bank or walking actively on the leaf litter. Often large individuals were observed resting in the mouths of their burrows, with merely the head protruding. It is possible that this is a foraging posture, and that the salamander in this position is awaiting prey. The burrows are variable in size, depending upon the size of the individual; the opening is usually sufficiently large to accommodate the salamander freely. However, since old root tunnels and other holes in the bank are employed, often the aperture is several times the size of the salamander itself. Gordon states (*in litt.*) that "We found them with their heads sticking out of decayed root tunnels, in the bank above the spring trickle. We found that in order to catch them it was necessary to stick a hunting knife in the ground behind them, thus blocking the tunnel." The agility of the salamander is here emphasized; although not particularly shy when the light is turned upon them, they seem especially sensitive to earth-borne vibrations when resting in their burrows at night, and will often retreat into the tunnels before capture is possible. Nicholls (personal communication) has noted juveniles on the leaves of the plant *Shortia* at night.

The series of 24 individuals, taken by the Conants shortly after dusk on the evening of October 5, 1952, was collected between 7:30 and 8:45 PM, and, even though the search for specimens continued for an additional hour, no further *clemsonae* were observed. The temperature was estimated to be about 15°C when the first salamander was taken, and was 13°C at ground level at 8:00 PM, and 14°C at 8:45 PM. The temperature of the previous day had probably been near 21°C, and the dirt roads in the Jocassee area were dry and dusty, indicating lack of recent precipitation. Conant states (MS) "The salamanders were apparently just leaving their burrows. One was found with its head protruding from an opening in the ground which was of sufficient diameter to admit a finger readily. Several had grains of reddish sand clinging to them, indicating they had just left burrows in a low bank along the trail. Although there were as many as three specimens in sight at one time and two on two other occasions, there were no obvious concentration points." These observations, in addition to my own, serve to show that these salamanders leave their burrows shortly after complete drakness. The length of the daily period of activity is certainly dependent on temperature and humidity, as will be discussed later. Occupation of burrows by other members of the *P. jordani* group has been pointed out by Chadwick (1940) and Brooks (1946).

Daytime collecting was carried on principally on the hillside above the Jocassee ravine, usually during the morning hours. The turning

of bark and logs revealed the salamanders on the moist earth. Due to the paucity of logs and plant debris of adequate size, the same cover was turned on every visit to the area. In spite of this repeated disturbance and the breaking of the firm contact between log and earth, salamanders were repeatedly found under the same logs, month after month. None was ever taken beneath the few rocks present. *P. j. clemsonae* seems able to tolerate far drier conditions beneath objects than other salamanders of the same species. On many occasions individuals were taken in extremely dry and dusty earth and leaf litter beneath the logs, while at other times they were encountered under objects in more moist earth. On January 10, 1954, an individual was taken under a log in a moist situation, where the temperature of the decaying leaf mold in which the salamander was embedded was 18°C.; the air temperature was 10°C. None was taken from beneath the few logs lying near the water in the ravine; here the earth was soggy and presumably too wet.

At a locality 1.5 miles northwest of Jocassee on the southwest side of the river were several piles of decaying shingles and rotting boards where both Kezer (*in litt.*) and I collected specimens. The center of each pile was always moist. At the same general locality, Kezer took four juveniles from moist leaf litter near a spring, and a series of 8 juveniles was collected by Thelma Howell, Ann Hawkins and Humphries, at Jocassee by raking through rhododendron leaf litter.

Occasional specimens have been found some distance from Jocassee. The individual from 1.1 miles north of the Jocassee Gun Club was taken beneath a large rock; this was the only one so encountered. In the vicinity of the summer houses in the Jocassee Valley, individuals have been collected beneath boards (on one occasion embedded in dry pine needles), actively foraging at night near springs, and under tar paper sheets.

On the exposed hillside at Joacassee, one juvenile and two adults were taken from beneath the bark of a large prostrate chestnut log in March. A later visit to this log in May yielded seven individuals from beneath the remaining bark. The ten specimens from the log and a juvenile crawling at night on a decayed stump at the spring at Jocassee are the only records of this salamander on objects above the surface of the ground.

P. j. clemsonae seems to be more abundant on the southeast side of Whitewater River than on the northeast side. The difference in plant cover of the two sides of the valley has already been pointed out, and this certainly accounts for the scarcity of individuals on the more exposed northeastern side of the valley. However, *clemsonae* does occur at especially favorable localities northeast of the river.

P. j. clemsonae has been collected at night when the air temperature at the collecting site was between 9°C and 29°C; temperatures were taken with a standard laboratory thermometer. However, even when temperatures within this range were encountered, the salamanders were not always abroad. The earliest record for salamander activity was at 7:45 PM on February 21, at an air temperature of 9°C. This individual was taken in proximity to a spring in a small sheltered ravine. On several occasions the search for salamanders lasted for three hours. Like the experience mentioned by the Conants, salamanders were to be found for only a limited period of the time. For example, on October 10, the ravine at Jocassee was searched between 8:00 and 11:00 PM; the first salamander was taken at 8:40 PM (air temperature, 13°C), and the last individual was seen at 10:10 PM. Although the area was searched until 11:00 PM, no additional individuals were observed; by this time the air temperature had dropped to 10°C. Again, on July 16, collecting was carried on between 8:00 and 10:00 PM; the first salamander was seen at 8:45 PM (air temperature, 26°C) and the last individual was taken at 10:00 PM. It is possible that with increasing fatigue the collector becomes less effective and fewer individuals are noticed in the leaf litter. However, it is also possible that there is an early period of concentrated activity on the part of the salamanders immediately after sunset and that this activity period continues for about two hours (under proper conditions) or until temperatures become unsuitably low. Whether these salamanders are active throughout the entire night is unknown.

The role of humidity in nocturnal activity is difficult to assess. It is of interest to note that Conant comments (MS) on the extremely dry conditions in the Jocassee region at the time he

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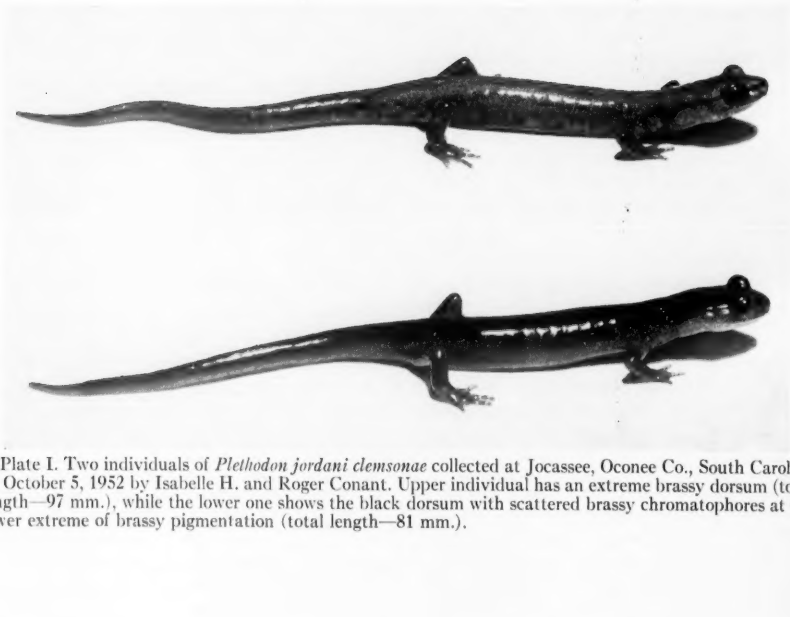

Plate I. Two individuals of *Plethodon jordani clemsonae* collected at Jocassee, Oconee Co., South Carolina on October 5, 1952 by Isabelle H. and Roger Conant. Upper individual has an extreme brassy dorsum (total length—97 mm.), while the lower one shows the black dorsum with scattered brassy chromatophores at the lower extreme of brassy pigmentation (total length—81 mm.).

collected 24 individuals. Likewise, on August 30, 1953, when 37 individuals were collected by Bell, Paulson, and myself, the Jocassee area was quite dry and no rain had fallen for at least a week. These two series are the largest series of *clemsonae* available at the present time. Conversely, during and after a continual heavy rain on September 26, 1953, no salamanders were seen in one and one-half hour's collecting, in spite of what would appear to be decidedly favorable conditions for amphibians. Unfortunately no record of the temperature was made on this date. Although it was cool, the temperature was undoubtedly within the limits recorded above for nocturnal activity. From these general observations it is seen that *clemsonae* is abroad at night during dry weather in preference to extreme wet conditions. Since the flora and topography of the region provide sheltered ravines which are always humid to some extent, even continual dry weather does not prevent this salamander from foraging at night because of the high humidity and sheltered conditions in the ravines.

An attempt has been made to ascertain if there is any seasonal movement of *clemsonae* in response to adverse weather conditions during the summer but unfortunately, insufficient numbers of salamanders were secured at each visit to make unequivocal generalizations. However, it seems apparent that during the summer months the salamanders are more concentrated in the cool, moist ravines than elsewhere and they are absent from under logs on the exposed hillside. In winter the ravine populations are less dense, and the animals are scattered over the entire region. This may mean that during hot weather the salamanders on the hillside move downward in tunnels in the earth beneath logs (rather than migrating at the surface to the ravines) and that they come to the surface only at night. In the ravines, winter night collecting was unproductive and no salamanders were seen therein, whereas during the summer months the ravines were by far the most successful collecting ground. I strongly suspect that there is a gradual seasonal movement in the Jocassee region, and that the open hillsides are deserted (except for a residual population) in the hot, dry summer months, and that the salamanders move to the ravines for that period. With the onset of the cooler, more moist winter, they expand their sphere of activity to the hillsides. Such movements probably occur from the ravines in October and to them in June.

Size and Structure

Plethodon j. clemsonae possesses the general configuration of members of the species *Plethodon jordani* (Plate I). In the Jocassee region it can be separated easily by the dorsal pattern, form, and differences in size and proportions (in adults) from *P. glutinosus*. The latter is decidedly larger and more stoutly constructed. There seems to be little sexual dimorphism in total length. Only individuals with complete and unregenerated tails were used in the following computations. The ten largest males in a sample of 169 average 142 ± 2.4 mm. (range, 133–156 mm. in total length, while the ten largest females average 137 ± 1.6 mm. (range, 132–149 mm.), but the differences is not significant. Bishop (1943: 240) indicates that the largest specimen recorded was a male measuring 149 mm. in total length; an adult female measured 142 mm., close to the maximum recorded size reached by females. The snout-to-vent measurement was made from the tip of the snout to the anterior angle of the vent. Employing individuals with lengths in excess of 40 mm., the ratio of snout-to-vent length to length of tail in 37 males averages .84 (range, .68–1.09), whereas this same ratio in 33 females averages .86 (range, .68–1.09). The two sexes have the same relative length of the tail.

In segregating adult from non-adult specimens, the following criteria were used. In males, a specimen was considered adult if it had (1) a well-developed mental gland, (2) well-developed anal papillae, and (3) the belly densely scattered with large circular glands, pale orange in life. This latter character develops chiefly in adult males but occasionally in adult females (9 out of 46 examined). It is more difficult to segregate females of breeding size from those which are immature than it is to segregate males. Of 46 females examined, only five contained eggs ready for deposition; these are considered adult. There are no secondary sexual characters which can be confidently employed to separate adult and juvenile specimens. Specimens with a snout-to-vent length of only 43 mm. contain small ova, but are not considered to be adults.

Thirty-four adult males average 57 mm.

(range, 45–69 mm.) in snout-to-vent length. The five females with large, yolk-laden eggs average 63 mm. (range, 58–66 mm.) in snout-to-vent length. This may indicate that, as in *P. glutinosus* (Pope and Pope, *op. cit.*: 260), males reach breeding condition at a smaller snout-to-vent length than do females but the discrepancy may be due to the small number of females containing eggs ready for deposition.

With respect to the size at which all three adult male characters are found together, it may be pointed out that specimens with snout-to-vent lengths of 45, 46, and 48 mm. lack either one or two of these characters. The largest of these individuals lacks a mental gland, while the 45 mm. specimen possesses only the anal papillae. The 46 mm. specimen has the ventral glands developed, but lacks both the papillae and mental gland. A fourth specimen has a snout-to-vent length of 57 mm., but lacks anal papillae, while possessing both ventral glands and mental gland. Most males with snout-to-vent lengths varying between 41 mm. and 47 mm. lack all three adult male characters. This suggests that the transition from the juvenile to adult condition in males occurs when the animals reach a snout-to-vent length slightly in excess of 40 mm.

There are 20 females whose snout-to-vent measurements lie within, or exceed the observed range of snout-to-vent length of egg-bearing females. These are probably fully adult but large ova were not present at the time of collection. The largest individual has a snout-to-vent length of 69 mm., equal to the largest male. Although there is no direct evidence at present, probably females mature at about the same body length as do males. Females taken during the period of egg development that measure less than 47 mm. have small ova and the oviducts are not convoluted and swollen.

In the light of the above, specimens with snout-to-vent length of less than 40 mm. are here considered juveniles. The smallest individual has a snout-to-vent length of 23 mm., while its total length is 44 mm. Its tail is complete. The ratio of snout-to-vent length to length of tail in 46 immature specimens averages .91 (range, .72–1.25). Juveniles have relatively slightly longer tails than do either adult males or females.

The width of the head has been employed in separating the sexes in some plethodontids but there are no significant differences in *clemsonae*. In 48 males and 46 females it averages, in both sexes, 9.3 mm. (range, 7.2–12.3 mm.).

In addition to the mental gland in adult males, other external secondary sexual characters are available for separating the two sexes. There is no observable difference in head shape or pointedness of the snout as in some members of the genus (*P. glutinosus*). Adult females have less stout legs than males. The shape of the vent differs in adults as follows: In males, the lips of the vent are plicate and pigmentless, the plicae extending anteromedially from the raised posterior lips. The raised borders of the vent do not extend for its entire length. Behind them is a small (about 2 mm. in length) section which is merely slit-like, where the vent margins are not raised. In females, the vent is a simple slit without raised lips. The plicae are present as in males but are not so pronounced. The immediate vicinity of the vent is without pigment for its anterior ⅓. In females with enlarged ova, the cloacal margins are enlarged and the plicae are more prominent, but no raised lips are formed as in adult males.

The usual number of costal grooves is 15-15, including those in the axilla and groin. Usually there is a divided or forked costal groove in the groin, and discrepancies in counts are often due to the absence of the posterior fork of this groove. Of 167 specimens examined, 149 individuals (89 percent) had the 15-15 groove count. Two immature salamanders had counts of 14-14 costal grooves, while three (a male, female, and juvenile) had a count of 16-16. The asymmetrical count of 15-16 occurred in 12 specimens, and of 16-17 in one specimen. Howell and Haskins (*op. cit.*: 33) list 92 individuals (82 percent) out of 112 *P. j. melaventris* having costal groove counts of 15-15; these data are roughly comparable with those on *clemsonae*.

The vomerine teeth of 166 specimens (Fig. 1) were counted. Forty-two individuals have the same number of teeth on both sides. To facilitate handling the data, the vomerine teeth numbers of both sides have been combined. The smallest number of teeth (6) was encountered in an immature individual, while the largest number (28) was counted in an adult male. The average number in 48 adult males in 19.0 (range, 12–28), and the average in 45 females (snout-to-vent length in excess of 40

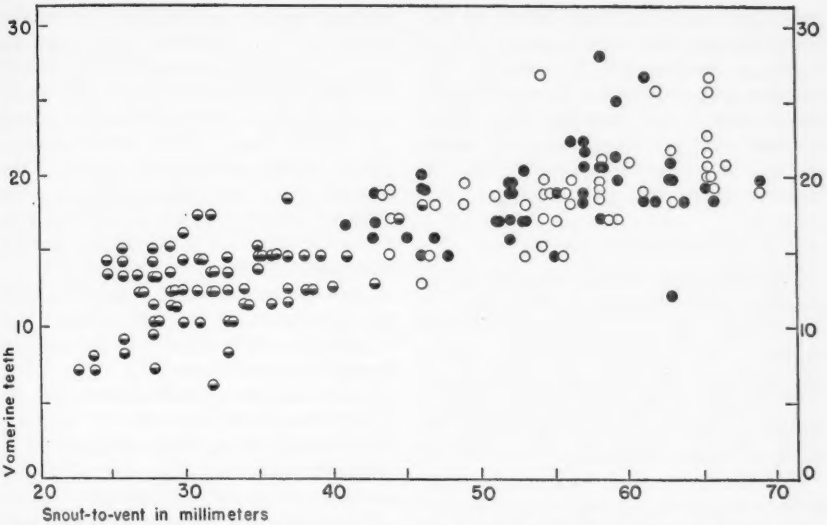

Fig. 1. Number of vomerine teeth plotted against snout-to-vent length in *Plethodon jordani clemsonae* Solid circles males, open circles females, and semi-solid circles juveniles.

mm.) is 19.2 (range, 13–27). Seventy-three juveniles have an average number of 12.3 vomerine teeth (range, 6–18). There is a high positive correlation (r = .66) between snout-to-vent length and number of vomerine teeth. This is contrary to the findings of Howell and Hawkins (*op. cit.*: 34) who state that in *P. j. melaventris*, "There was no significant correlation between total number of vomerine teeth and size of the individual."

Pigmentation

Brimley (*op. cit.*: 73–74) diagnosed *clemsonae* as "A black Plethodon of the *jordani-shermani-metcalfi* group without red pigment but usually with some white pigment overlaying the black pigment on the back; with about ten teeth in each vomerine series and with pale throat and very dark belly." The statement that there is some white pigment on the dorsum is undoubtedly due to the fading of the brassy pigment before the salamanders reached Brimley. Bishop (*loc. cit.*), however, stated that *clemsonae* has many large, irregular light gray, lichen-like patches scattered over the dorsal surface of the head, trunk, and basal part of the tail, and this is a closer approximation to the color in life. It remained for Hairston and Pope (*op. cit.*: 270–271) to define in detail the coloration. They stated that "All of our eleven specimens from Jocassee have conspicuous brassy specks crowded together on the dorsum. In some, these markings cover the back; in others, they are reduced to more or less discrete areas." The coloration is in reality far more variable than these investigators indicate, and more abundant material makes analysis of pattern now possible.

Salamanders collected were killed by immersion in chlorotone, and were examined for details of coloration immediately after fixation in formalin. Early in the study it was discovered that material transferred into 65 percent alcohol after fixation in formalin and subsequent washing in water, quickly lost all semblance of pattern and guanoid coloration except for lateral white pigment. In fact, specimens stored for less than two months in alcohol appear uniformly black dorsally. Grobman (*op. cit.*: 294) has commented on the evanescence of the dorsal pattern in the type series after sixteen years preservation. To avoid undue fading of the brassy pigments, the material was stored in formalin while the present study was in progress. This seems most satisfactory, since specimens thus stored for over a year still retain some of the original pattern, and the brassy pigmented areas now are grayish.

The coloration and pattern of 85 specimens

have been studied on freshly killed and preserved material. This series is comprised of 28 males, 33 females, and 24 juveniles. The following categories of dorsal pigmentation and lateral white spotting have been used. These are admittedly arbitrary, and grade imperceptibly into one another, but seem satisfactory in expressing the variation.

Dorsal Coloration

1) Entirely black, with no brassy chromatophores (no males, 2 females, no juveniles).

2) Lightly flecked with a few brassy chromatophores, often distinguishable only under magnification (7 males, 3 females, 3 juveniles).

3) With scattered but heavy brassy blotches, sometimes lichenoid, but always discrete (8 males, 21 females, 7 juveniles).

4) Uniformly covered with small brassy flecks or dots, giving the general appearance of brassy (10 males, 6 females, 14 juveniles).

5) Heavily and uniformly covered with brassy flecks or dots, giving the general appearance of a muddy or dull-brassy colored animal (3 males, 1 female, no juveniles).

White Spotting on Sides

1) Absent—no white spotting on sides (6 males, 3 females, 2 juveniles).

2) Scarce—scattered white dots on sides, usually restricted to the sides in the region of the axilla or groin (11 males, 13 females, 8 juveniles).

3) Moderate—white spots scattered and discrete, but obviously visible (6 males, 8 females, 8 juveniles).

4) Heavy—white spots either numerous and boldly present against the black background or fused into a solid white band over the costal grooves (5 males, 9 females, 6 juveniles).

In the present specimens, dorsal pattern 3 shows the highest frequency. This is especially true of females, since 21 of the 33 specimens examined have the bold dorsal blotching. The juveniles show a heavy preponderance of individuals with uniformly flecked dorsal surfaces, and the greatest number of males (10) falls into this category also.

The two extremes in coloration of adults may be judged from the following notes taken immediately after death. (1) "Dorsum black, no brassy on back or legs. A very few white spots on cheek and one white spot on one side. Looks like *P. j. melaventris*." (2) "Entire dorsum from snout to entire tail (which is broken) overlaid with fine brassy dots, giving a muddy appearance. Brassy extends from dorsum over sides to belly, and no white dots on sides apparent. Cheeks, gular region, and chest likewise brassy and not white. Belly has a few scattered brassy blotches. Legs and arms brassy dorsally. Sides of tail brassy. No white on animal at all. An extreme individual." Thus, at the type locality occur individuals which run the entire gamut of dorsal coloration from salamanders which resemble *P. j. melaventris* through the usual *clemsonae* pattern to individuals which are virtually brassy over the entire dorsum. It may be argued that the specimens from Jocassee which resemble *P. j. melaventris* are indeed that salamander. This possibility will be discussed later.

Viewed laterally, individuals usually show some degree of white spotting, although such white spotting is absent in 11 of the 85 examined. In 20 individuals, this white spotting is regarded as heavy, and in one specimen the white 'spots' are fused into a lateral white band at the lower end of the costal grooves. The brassy chromatophores blend gradually into those contributing to the white spots, so that on the upper sides a mixing of the two pigment-bearing cells is apparent. White chromatophores occur sporadically on the venter, which ranges from pale gray or whitish in most juveniles to black in adults. The tail is flecked or mottled with brassy either for its entire length or for varying portions thereof. Such variation depends rather on the degree of pigmentation on the dorsum of the body rather than on size or sex, for the dorsal body pattern is carried out in a modified condition on the tail, and those specimens which uniformly flecked backs have heavily pigmented tail. White spots occur occasionally on the sides of the tail.

The dorsal aspect of the appendages is variously mottled or flecked with brassy, and again this is correlated directly with the degree of dorsal pigmentation. The head is usually dotted with brassy above the canthal line, but extreme individuals have brassy flecks on the lips and sparingly on the throat. The cheeks have white chromatophores toward their ventral margins, and this white pigment grades quickly into

brassy dots or blotches toward the dorsal portion of the cheek.

In summary, *clemsonae* may be said to have usually some degree of brassy pigmentation on the dorsum, grading into white spotting on the side. The legs and arms usually have some brassy markings on their dorsal aspect. The cheeks are usually whitish below and brassy above, and the venter varies between whitish or gray and black.

In addition to the structural resemblance between specimens of *clemsonae* and the remaining members of the *jordani* group, there are two points based on pigmentation which affirm the relegation of *P. clemsonae* to subspecific status under *P. jordani*. The presence of *melaventris*-like individuals at Jocassee is evidence for this relationship. Duellman has checked certain specimens in the University of Michigan Museum of Zoology for me. Among them are three specimens (UMMZ 97729 (2); 97732), collected by J. R. Bailey, in June and August, 1947, from the Jocassee region. They were identified as *P. melaventris* and almost certainly at the time of collection lacked any brassy markings on the dorsum, otherwise Bailey probably would have identified them as *clemsonae*. Of course at present, even the four specimens collected by Bailey on those dates and then assigned to *P. clemsonae* now lack markings, and thus the two lots of material are virtually indistinguishable. The taking of two adult females, which likewise lacked any brassy markings, during the present study, as well as several specimens whose brassy chromatophores were extremely reduced and had to be observed under the microscope (in several instances the actual number of chromatophores, usually less than 10, could be counted), shows that such unmarked individuals occur at Jocassee. There are two alternatives: 1) that *clemsonae* is an entity distinct from the *P. jordani* complex of races, and that *clemsonae* and *P. j. melaventris* occur sympatrically at Jocassee, or 2) that these *melaventris*-like individuals are part of the normal variation in *P. j. clemsonae*, and they thus affirm the relationship between these two forms. The latter course is here adopted since, in the large series at hand, every sort of variation in color patterning can be observed, between unmarked individuals (black dorsally) to those with varying degrees of brassy pigmentation. It is possible that these few *melaventris*-like individuals represent invaders of *P. j. melaventris* from higher elevations, but if an actively reproducting population of *melaventris* were present at Jocassee, it would seem likely that more unmarked specimens would have been taken or observed.

So far as known, no brassy-flecked specimens of *Plethodon jordani* have been reported from within the ranges of the other races of this species. Hairston (1950: 269) in the description of *P. j. teyahalee* comments upon the "brassy-like" coloration of sides, cheeks, and throat of this form. He states that this coloration is reminiscent of, but not exactly like, the brassy spotting of *clemsonae*. In the summer of 1953, two individuals of *P. j. rabunensis* were taken by Paulson, Bell, and myself, on Rabun Bald, Rabun County, Georgia. They exhibited brassy spotting much as *clemsonae*. Unfortunately, these specimens were preserved along with the remaining, normally colored specimens of *P. j. rabunensis*, and their color has long since disappeared. Thus they are presently indistinguishable from other *P. j. rabunensis*. Both were collected on Rabun Bald at high elevations in the proximity of normal *P. j. rabunensis*. From these meager data it would seem that the genetic potential for such coloration is present but seldom expressed in populations of *P. j. rabunensis* which occur immediately to the west of the range of *clemsonae*. If such genes for brassy dorsal spotting are present in other populations belonging to the *jordani* group, it is conceivable that they reach maximum expression only locally in Jocassee Valley in the population currently known as *clemsonae*. This situation in *rabunensis* serves further to support the status of *clemsonae* to the east, *P. j. melaventris* to the north, and an unnamed, heavily white-spotted form which occupies the Georgia mountains to the west.

Eggs and Young

The eggs of no member of the *P. jordani* complex of subspecies are known. Efforts to discover eggs and attending females of *clemsonae* have failed. However, data on the time of egg laying can be obtained from adult specimens. The four females which are laden with large ovarian eggs were secured on February 21, March 13, and May 15 (two individuals). Other females collected on and between these

dates showed no enlarged ova, and were either immature or spent. Presumably egg deposition takes place in spring, between March and May. Howell and Hawkins (*op. cit.*: 36) state that in *P. j. melaventris*, females with enlarged ova were collected in July and late September. The earlier dates for egg development in *clemsonae* may be a response to the lower elevation; Pope and Pope (1951: 142) note differences in ovarian condition of female *P. ouachitae* at two elevations. In any event, as in *P. j. melaventris*, the laying season is an extended one. The four gravid females contained 24, 20, 17, and 17 enlarged, well-yolked ova. These data are at variance with those of Howell and Hawkins (*loc. cit.*) who state that in *P. j. melaventris* "egg complements of seven specimens ranged from 64 to 137, the average being 94.7." This discrepancy is doubtless due to these workers counting all ova in the ovary, and not merely the enlarged ova ready for deposition.

The month of collection and the snout-to-vent lengths of 149 individuals of *clemsonae* have been plotted in Table II. The table shows that juveniles appear first in June, and are still present in October. It is probable that eggs deposited in early spring hatch by June, and eggs deposited later continue to hatch throughout the summer. During the following autumn these juveniles gradually reach the size of young adults (40 mm.); juveniles which hatch early in the season approach the size of young adults by October of the same year. The separation between juveniles and young adults in June, July, and August samples is readily made. By October this separation is made with difficulty and in November separation is no longer possible. Judging from present samples, juveniles have reached young adult size by November.

If these data have been correctly interpreted, they differ from the results obtained on *P. glutinosus*, *P. ouachitae*, and and *P. yonahlossee*. Regarding *P. glutinosus*, Pope and Pope (1949: 259–9) state that "It is unlikely that any young of the year are included in our series, since the four smallest individuals measure 42.4 to 45 mm. in total length and the well-pigmented larva measured by Noble and Marshall. . . was only 16 mm. from tip to tip. The four smallest specimens, moreover, were collected from July 27 to August 2, inclusive, and therefore as hatchlings could not have had much time for growth." Females were assumed by these authors to mature when just or not quite three years old. These authors record 33 juveniles with snout-to-vent length ranging between 22 and 31 mm.; and assumed them not to be young of the year. Pope (1950: 94–5) in his study of *P. yonahlossee*, discerned three age groups, of which the first is comprised of juveniles in their first summer after the one in which they were hatched. These juveniles measure 20 mm. to 39 mm. in snout-to-vent length, and were collected July 12–14, at a time when hatchlings of the year would have had little time to grow. Pope and Pope (1951: 140) show that their sample of *P. ouachitae* lacked the usual large number of juveniles, but they assume that the growth rate of *P. ouachitae* is like that of *P. glutinosus* and *P. yonahlossee*.

TABLE II

SIZE IN RELATION TO MONTH OF COLLECTION IN *Plethodon jordani clemsonae*

Month	Snout vent length in mm.									
	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70
June		1					3	2	1	
July	4	8			2	1			1	
August	1	16	8		5	2	3	3	1	
October		1	8	2	1		5	2	3	2
November				1	1		3	6	2	1
January				2		1			1	
February			1	1	1		1	2	2	
March				4		1	5	3	2	1
April				1		1	2			
May					3	1	4	3	4	2

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Department of Biology, Albright College, Reading, Pennsylvania

Correlating Costal Grooves with Trunk Vertebrae in Salamanders

Richard Highton

THE use of costal grooves as a meristic character in the study of variation in salamanders has not always been satisfactory. Counts made on specimens of the same form by different investigators do not always agree. Some workers count only the grooves between the front and hind limbs, while others include those in the axillary and/or inguinal regions. When two grooves run together at the groin, some would count both as one groove, others would count the two separately. Many workers have not stated the method used and there have been inconsistencies in method even in standard reference works on North American salamanders. Pope (1950: 102) has indicated the existing confusion by stating that "variation of a magnitude of one or two grooves will be meaningless unless the same worker has made all counts and done so with great care."

Counts of vertebrae made on 1181 salamanders of the genus *Plethodon* in connection with a study of the systematics of that genus have shown that in many taxa, over 80 per cent of the individuals of the same species or subspecies possess the same number of trunk vertebrae,[1] with the remaining specimens varying by only one vertebra more or less than the modal class. An accurate method of estimating the number of trunk vertebrae by counting the costal grooves would therefore be useful in detecting differences in trunk segmentation without the necessity of preparing skeletons or taking radiographs of large series of salamanders of each of the populations to be compared. The modal number of trunk vertebrae in the forms of the genus *Plethodon* varies from 15 to 22. The costal grooves of several specimens of each species were compared with radiographs of their vertebral columns in order to determine the relationship of the costal grooves and vertebrae.

Results

The atlas is not related to any costal groove. The first trunk vertebra is located just anterior to the gular fold but its rib does not appear to

[1] Since there is little regional differentiation of salamander precaudal vertebrae, Francis (1934) suggested that all precaudal vertebrae, except the atlas and the sacrum, be called *trunk vertebrae.*

be associated with the gular fold or with any of the costal grooves. The rib of the second trunk vertebra is located in the myoseptum associated with the first costal groove. The position of this groove varies somewhat, but is usually close to the front limb insertion. If the first costal groove is poorly defined or absent, as often occurs when it is located directly over the front limb, it should be counted, as the space corresponds to a vertebra whether the groove is visible or not. The individual variation in the position of the first costal groove is probably due to the variation in the position of the pectoral girdle relative to the vertebrae. The girdle may be located opposite the second trunk vertebra, between the second and third trunk vertebrae, or opposite the third trunk vertebra. The ribs of the third trunk vertebra extend posteriorly so that the second costal groove is always posterior to the front limbs.

There is a one-to-one relationship between the remaining precaudal vertebrae and the costal grooves, except in the case of rare aberrations (one vertebra possessing two or more pairs of ribs, or one vertebra possessing a rib on only one side, in which case the costal grooves always correspond to the number of ribs). The last presacral vertebra (usually the only trunk vertebra that does not possess ribs) is represented by the groove just anterior to the insertion of the hind limbs. Often this groove joins the one just preceding it so that on the lower sides there is only one groove. Both grooves should be counted, since they correspond to two separate vertebrae. The groove over the hind limb insertion (sometimes weakly developed or absent) corresponds to the sacral vertebra, and each groove on the tail corresponds to a caudal vertebra.

There is much more individual variation in the position of the sacral vertebra in relation to the pelvic girdle than there is in the relation of the shoulder girdle to the second and third trunk vertebrae. The sacral vertebra may be located so far anterior to the pelvic girdle that the first caudal vertebra is opposite the hind limbs. It may also be slightly anterior, opposite, or slightly posterior to the pelvic girdle. Occasionally when it is posterior to the girdle, the costal groove corresponding to the last trunk vertebra is located over the hind limb in the usual position of the sacral vertebra. This is the major source of error in attempting to accurately correlate the number of costal grooves with the number of trunk vertebrae. Fortunately, however, less than 5 per cent of the specimens examined were in this category.

Costal groove counts were made on 224 specimens of eleven species of the genus *Plethodon* (including specimens possessing 15 to 23 trunk vertebrae), and 94 per cent of the counts accurately represented the number of trunk vertebrae obtained from X-ray photographs. Since the first trunk vertebra is not associated with a costal groove, the number of costal grooves is one less than the number of trunk vertebrae. It would therefore appear that the number of costal grooves can be used to obtain an accurate estimate of the number of trunk vertebrae in the genus *Plethodon*.

Occasionally the sacral rib may articulate with one vertebra on one side of the animal and with the following vertebra on the other side. Rarely, there are two sacral ribs issuing from two successive vertebrae on the same side of the animal. The suggested method of counting costal grooves is of no value in detecting such abnormalities.

In order to determine whether the method of estimating the number of trunk vertebrae from the costal grooves in *Plethodon* will work in other salamanders, costal groove counts of small series of specimens of species in other genera were compared with radiographs of their vertebral columns. The relationship of the number of vertebrae to the number of costal grooves was similar to that in *Plethodon* in the majority of species studied. These included *Aneides flavipunctatus*, *A. lugubris*, *A. hardyi*, *Batrachoseps attenuatus*, *B. pacificus*, *Desmognathus monticola*, *D. ochrophaeus*, *Ensatina eschscholtzi*, *Eurycea bislineata*, *E. multiplicata*, *Hemidactylium scutatum*, *Stereochilus marginatus*, *Typhlomolge rathbuni*, and *Typhlotriton spelaeus*.

In *Manculus quadridigitatus* and *Chiropterotriton chiroptera*, the first rib is associated with a costal groove located posterior to the gular fold, but anterior to the front limb. If this groove is counted, then the number of costal grooves is equal to the number of trunk vertebrae. In none of the other genera studied was the first pair of ribs associated with a costal groove.

In nine species of *Ambystoma* (*annulatum*,

cingulatum, *gracile*, *mabeei*, *macrodactylum*, *opacum*, *talpoideum*, *texanum*, and *tigrinum*), the number of costal grooves is usually two less than the number of trunk vertebrae. Examination of radiographs showed that the sacral vertebrae of *Ambystoma* are usually located posterior to the hind limb insertions. The costal groove located directly over the hind limb is associated with the last trunk vertebra, resulting in an underestimate of the number of trunk vertebrae when the method used in *Plethodon* is applied to the genus *Ambystoma*.

Preliminary observations made on the above genera indicate that as in *Plethodon*, there appears to be a high frequency of occurrence of the modal number of trunk vertebrae in each taxon. It is suggested that in future systematic studies on salamanders in which segmental variation is apparent, a small series of specimens should be studied by means of X-ray photographs in order to determine the relationship of costal grooves to the trunk vertebrae. After the relationship is correctly established, costal groove counts will be much more valuable as a tool for studying segmental variation in these amphibians.

Summary

An accurate estimation of the number of trunk vertebrae in salamanders of the genus *Plethodon* can be made by counting all grooves posterior to the gular fold and anterior to the hind limb, including as separate grooves those that may run together on the groin. This method resulted in a costal groove count one less than the number of trunk vertebrae in 94 per cent of 224 specimens studied. Preliminary studies indicate that the relationship of the costal grooves to trunk vertebrae is similar to that in *Plethodon* in several other salamander genera, but is different in *Manculus*, *Chiropterotriton* and *Ambystoma*.

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Department of Zoology, University of Maryland, College Park, Maryland.

A New Species of the Snake Genus *Sibon* from Ecuador

James A. Peters

Immediately obvious even to the neophyte in Neotropical herpetology is the impact that Emmet R. Dunn has had in this field. It is impossible to work in any detail without consultation of his considerable published work on the area, such as, for example, his "Los Géneros de Anfibios y Reptiles de Colombia," published in various issues of Caldasia, or his summary volume on the American Caecilians, published by the Museum of Comparative Zoology. His published works give all who read them a clue to his grasp and familiarity with his subject, but only those of us who have corresponded with him concerning shared problems can know the generosity with which he offered his time and knowledge. When I first wrote Emmet R. Dunn concerning my work with the snakes of the subfamily Dipsadinae, his reply indicated that he had not only been interested in the problem, but also had begun work on a revision of the group himself. Upon receipt of my letter, he immediately offered to let me examine his notes on all specimens he had examined and to help in any other way possible. This spontaneous relinquishment of his prior claim was characteristic of his professional attitude.

In view of his long-term interest in these

snakes and his long association with the problems of Neotropical herpetology in general, it gives me considerable pleasure to be able to describe a new species of the genus *Sibon* in his honor.

Sibon dunni sp. nov.

HOLOTYPE.—University of Michigan Museum of Zoology 92068; male from Pimanpiro, San Nicholas, Province of Imbabura, Ecuador, collected by Philip Hershkovitz.

PARATYPES.—University of Michigan Museum of Zoology 92069–72; same collection data as for holotype.

RANGE.—Known only from the type locality in Ecuador.

DIAGNOSIS.—This species is characterized by its low labial count; the presence of only a single labial posterior to the last one entering the orbit; the low ventral and subcaudal counts; and its unique color pattern.

DESCRIPTION.—Rostral broader than deep, visible from above; length of internasals three-fourths that of prefrontals, which enter orbit; frontal longer than wide, considerably shorter than parietals; nasal partly divided; loreal enters orbit; preoculars none; postoculars two; suboculars none; primary temporal one; secondary temporals two; tertiary temporals absent; upper labials six, with fourth and fifth entering orbit; sixth upper labial larger than others, in broad contact with postocular, and primary and secondary temporals. Lower labials eight or nine, one pair in contact behind mental, five pairs in contact with first pair of chin shields; three pairs of chin shields.

Ventrals 142–145 in males, 136–139 in females; anal entire; subcaudals 60–62 in males, 48–56 in females. Dorsal scale rows 15 from level of fourth or fifth ventral to anus; vertebral row moderately enlarged; caudodorsals in males, *6* 2 + 3 (16–23) *4* 1 + 2 (38–51) *2* (60–62) and females, *6* 2 + 3 (12–16) *4* 1 + 2 (39–43) *2* (48–56).

Maxillary teeth 14; palatine teeth 9; pterygoid teeth 18 (all from a single specimen).

Snout-vent length in largest male (holotype) 304 mm., in largest female 187 mm., and in smallest individual 128 mm.; tail measurements of these individuals are, respectively, 98, 52, and 36 mm.

Dorsal ground color light brownish-cream, with a vertebral series of small, irregular, ovate, chocolate-brown spots, often broken and jagged in outline, that are wider than long and are confined for the most part to vertebral and paravertebral scale rows; all other dorsal scales with at least some trace of chocolate or dark brown markings on anterior edges, giving reticulate appearance where not spotted; occasional massing of dark color laterally produces small spots, usually directly opposite vertebral spot; amount of dark color on individual scales increases from ventrals to vertebral row. Belly cream, either immaculate or with very small, irregularly arranged, widely spaced, brownish spots, increasing in number posteriorly; tips of ventrals with brown edges, as on dorsal scales. Tail as body, with more pigment ventrally; zig-zag line along midventral sutures of paired subcaudals more or less marked.

Dorsum of head chocolate brown, strongly variegated with cream-white, most prominent on occiput and snout, frontal and parietals brown for most part; sides of head variegated with brown and cream, with labials entirely cream except for large, well-marked brown spot on last labial. Chin, throat, and lower labials immaculate or with poorly defined small brown spots and occasionally with dark labial sutures.

DESCRIPTION OF HOLOTYPE.—(Characters that do not differ from the general description above are not repeated). Nasal completely divided; lower labials eight; four scales between parietals and enlarged vertebral scales; ventrals 142; subcaudals 62; hemipenial sheath extremely lightly pigmented; dorsal scale reduction:

$$(5)\ 15\ \frac{V + 7\ (142)}{V + 7\ (140)}\ 13\ (142).$$

Caudodorsal reduction:

6 2 + 3 (16) *4* 1 + 2 (38–41) *2* (62).

Measurements (mm.): Body length 304; tail length 98; rostral width 2.9, depth 2.4; internasal width 3.4, length 1.5; prefrontal width 5.0, length 2.5; frontal width 3.2, length 4.1; parietal length 6.3.

INDIVIDUAL VARIATION.—There are no variations in the dorsal head scales and little in the scales on the side of the head. The type is

the only individual with a completely divided nasal, all others have partly divided nasal scales. No. 92071 has a tiny extra scale between the postoculars, primary temporals and labials. No. 92070 has five labials on the left side, with the third and fourth entering the orbit, while 92069 has seven upper labials on both sides, although it is normal in that the fourth and fifth enter the orbit. It is the only specimen with other than a single labial posterior to those entering the orbit. The lower labials are 8-8 in two specimens, 9-9 in two, and 8-9 in one.

The type is the only specimen showing any dorsal reduction of scale rows, and, as seen in the formula above, this takes place at the anus. There are no irregularities in caudal reductions.

REMARKS.—This species apparently has a very restricted range in the highlands of Ecuador. It is peripheral to the range of the genus *Sibon* as a whole, a characteristic it shares with *Sibon sanniola*. The two species are quite similar in many respects. Both show great reduction in the number of body segments as compared with all other species in the genus, as shown by ventral and subcaudal counts. Both are characterized by a reduction of the dorsal pattern to an indefinite number of vertebral spots. The Yucatecan species, *sanniola*, is, in addition, a very diminutive species. The material of *dunni* is too scanty to give an indication of size, but all five specimens seen are small, and it is possible that the reduction in total number of body segments is accompanied by a decrease in absolute size as well.

It will be noted that I do not consider the genus *Sibon* to be monotypic, although recognition of this genus as monotypic provided the basis for Dunn's study on quantum evolution (1951). The reasons for my reallocation of many of the species of the subfamily Dipsadinae will be more thoroughly discussed in a monograph of the group, which is in press. There are three species groups within the genus *Sibon*, two of which are composed of series of allopatric species in Central America. The third is made up of *Sibon nebulata* and its subspecies, the snake previously known as *Tropidodipsas carri* Shreve and *Sibon dunni*.

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DEPARTMENT OF BIOLOGY, BROWN UNIVERSITY, PROVIDENCE 12, RHODE ISLAND.

The Taxonomic Status of Some Southwestern Skinks of the Multivirgatus Group

JOHN S. MECHAM

THREE species of the *Eumeces multivirgatus* group are currently recognized in the American southwest. *Eumeces multivirgatus* has the largest range of the three, and is best represented in collections. The other two, *Eumeces taylori* and *Eumeces gaigei*, are rare, and their taxonomic status is poorly understood. All three forms have been recorded in the Guadalupe Mountains of western Texas and southern New Mexico, a surprising and unlikely circumstance in view of their close similarity in structure and habits.

During the course of an ecological survey of the reptiles and amphibians of the Guadalupe Mountains, a large series of lizards of this group was obtained. On the basis of this material it was apparent that only one species of the *multivirgatus* complex was present in the region. Previous recognition of three species where only one existed was the result of confusion caused by two distinct pattern phases coupled with ontogenetic pattern change. This discovery has necessitated a review of the entire *Eumeces gaigei-taylori-multivirgatus* problem.

I would like to express my gratitude to all those individuals and their respective institutions responsible for the loan of material used

in the study. Dr. W. Frank Blair read the manuscript and Mr. and Mrs. Roger Conant generously allowed the use of the photograph (Plate I, C). Messrs. Robert H. DeWolfe and Jim Tamsitt assisted in the field work.

Research leading to this paper was accomplished during tenure as a National Science Foundation fellow at the University of Texas, Austin, Texas.

Abbreviations used in the text are: AMNH, American Museum of Natural History; KU, University of Kansas Museum of Zoology; EHT-HMS, Edward H. Taylor, Hobart M. Smith Collection; UCMVZ, University of California Museum of Vertebrate Zoology; UCM, University of Colorado Museum; UMMZ, University of Michigan Museum of Zoology; UA, University of Arizona; USNM, United States National Museum; ANSP, Academy of Natural Sciences of Philadelphia; CNHM, Chicago Natural History Museum; UCLA, University of California, Los Angeles; TNHC, Texas Natural History Collection.

The Status of *Eumeces gaigei*

Mosauer (1932) recorded the first four specimens of the *Eumeces multivirgatus* group from the Guadalupe Mountains. Two of these he assigned to the Mexican species *Eumeces humilis* Boulenger. The others were tentatively identified as *Eumeces multivirgatus* Hallowell. Taylor (1935) described *Eumeces gaigei* as a new species with type and paratype from Taos, New Mexico. He assigned the larger of the two *multivirgatus* collected by Mosauer to the new form, as well as a badly dried specimen in the American Museum, also from the Guadalupe Mountains.[1] At the same time he reaffirmed the identification of Mosauer's other specimen as *Eumeces multivirgatus*. Few additional specimens of *Eumeces gaigei* have been found. Bailey (1937) reported three specimens from Grant County, New Mexico, although Smith (1946) believed that one of these, an immature individual with a light middorsal stripe, was a *Eumeces multivirgatus*.

As understood by Taylor (1935, 1936) and Smith (1946) *Eumeces gaigei* is distinguished from *Eumeces multivirgatus* primarily by the absence of a median dorsal light line, both in the adult and young. In addition, a dark band or line which is well developed on adjacent portions of the first and second scale rows in *Eumeces multivirgatus* is reduced to a dim and narrow line in *Eumeces gaigei*. The supposed absence of the distinct median light line in the young is given particular significance, although evidently the only evidence is based on the poorly preserved American Museum specimen. Taylor gave no exact size for this individual, and described it simply as a young example, possessing light flecks along the median portion of the body, but in no sense a median line. Scalation characters of known *Eumeces gaigei* are very similar to *Eumeces multivirgatus*, and fall within the range of variation of that species.

Among the material collected by the writer in the Guadalupe Mountains are ten striped skinks of the *Eumeces multivirgatus* group. A wide range of sizes is represented, and a marked pattern change with age is clearly shown. On the basis of existing definition of characters, the younger individuals would be identified as *Eumeces multivirgatus*, whereas the adults fit perfectly the description of *Eumeces gaigei*. Although the differences between adults and young are great, there can be no doubt whatsoever that all belong to the same species, as intermediate pattern types are represented.

The smallest specimens (snout-vent lengths of 35 and 36 mm.) are quite dark, and have a clearly defined middorsal light stripe on adjacent halves of the first dorsal scale rows, continuing forward and forking faintly on the head. A more vivid and contrasting dorsolateral light line runs down the middle of the third scale row, and extends forward over the eye. Another light line extends back from the ear opening, passes over the arm, and continues faintly along the sides of the body to the groin. There are also longitudinal black lines or stripes which are only faintly visible because of the dark ground color. One occupies adjacent portions of the first and second scale rows, although mostly confined to the first. Another dark line runs along the inner portion of the third scale row, bordering the dorsolateral light stripe. A dark broad band extends along the sides, bounded dorsally by the dorsolateral light stripe, and ventrally by the very faint lateral light line.

[1] I have examined the AMNH material of this group, but have not seen the specimen to which Taylor referred. Dr. Zweifel informs me that there are no specimens of *E. gaigei* in the collection.

The important changes which take place with age are: (1) a general lightening of the ground color to an olive brown, resulting in greatly increased contrast of the dark lines; (2) a gradual loss of the light middorsal line by invasion of the ground color, resulting at first in loss of definition along the edges of the line, and eventually the complete loss of the line; (3) a reduction in width of the dorsal dark line between the first and second scale rows. In one of the largest specimens this line has completely disappeared; (4) a rapid lightening of the dark lateral band, which gives way to two or three dark lines. One of these runs along the outer edge of the dorsolateral light line, and is confined to the third scale row. Another, usually wider and more diffuse, occupies proximal portions of the fourth and fifth scale rows. A third weakly developed, narrow dark line may or may not occur between the fifth and sixth scale rows. The lateral light line is retained on the neck but lost on the body.

The light middorsal line is well defined in the two smallest examples, and the ground color is still dark. Another specimen 38 mm. in length is perceptibly lighter, and the middorsal stripe has become diffuse; in yet another individual measuring 48 mm. the adult coloration has been attained, although there are still traces of the middorsal light stripe anteriorly, and the black dorsal stripes are bold and contrasting. An adult measuring 59 mm. has completely lost the middorsal light stripe, and only the faintest traces of the dorsal black stripe remain between the first and second scale rows.

The Guadalupe Mountain specimens identified by Taylor as *Eumeces multivirgatus* and *Eumeces gaigei* (with the exception of the American Museum specimen), the paratype of *Eumeces gaigei*, and the three *gaigei* reported by Bailey have been compared, and were found to agree in pattern with the writer's series. There is no reason to suppose that they are anything but the same species. It must be concluded, therefore, that what has been called *Eumeces gaigei* may possess a light middorsal stripe in the young, and that intermediate stages may have strongly defined dorsal dark lines. Recognition of these facts made the validity of *Eumeces gaigei* extremely dubious. In an effort to ascertain the true status of this form, much of the available material of the *multivirgatus* group has been examined. The dark line on adjacent portions of the first and second scale row was found to be subject to a high degree of variation in New Mexico populations, and consequently cannot be regarded as diagnostic. No other characters were found which would serve to separate *Eumeces gaigei* from *Eumeces multivirgatus*, and there is, therefore, no basis for recognition of *gaigei* as a distinct species. More detailed discussion of the characters involved is reserved for the section under geographic variation.

The Status of *Eumeces taylori*

Smith (1942) pointed out certain differences between the Mexican *Eumeces humilis* and the Guadalupe Mountain specimens assigned to that species, and proposed the new name *Eumeces taylori* for the Guadalupe material. At that time only three specimens were known: the two collected by Mosauer and another taken by Taylor on the Black River, Guadalupe Mountains. Bundy (1951) recorded a specimen from Chaves County, New Mexico, and Brown (1952) described another individual from Pecos County, Texas. John Neess, Roy E. Bundy, and Delbert Meyer have the description of a second specimen from Chaves County in press.

Eumeces taylori is quite distinctive in appearance, and the known specimens may be readily separated from *Eumeces multivirgatus* (including *gaigei*) on the basis of the almost complete absence of pattern. The animal is a uniform olive brown above with an indistinct dark streak on the side of the head and body. Scale characters so far as known closely resemble those of *Eumeces multivirgatus*.

The writer has taken seven specimens in the Guadalupe Mountains which are referable to *Eumeces taylori*. In addition to these specimens and the three reported in the literature, five other *taylori* have come to light in collections from New Mexico. The University of California, Los Angeles collection contains two specimens from Sitting Bull Canyon, Eddy County, and a single example from the Sandia Mountains, Bernalillo County. There are single specimens in the University of California Museum of Vertebrate Zoology from Carlsbad, Eddy County, and Roswell, Chaves County. All the known specimens of *taylori*, with the

exception of the type, have been available to the writer for comparison.

With the exception of UMMZ 70103, a very young and poorly preserved example, all the Guadalupe specimens are subadult or adult in size. All exhibit a high degree of uniformity in the reduced pattern. The only markings are the indistinct dark streak on the sides, the pale throat and lips, and faint indications in the smallest specimens (45.7, 48.7 mm. snout-vent) of a light and ill defined streak over the eye. All the material is easily and definitely distinguishable on the basis of pattern from the striped *multivirgatus* (including *gaigei*) of the region, and none of the specimens appear intermediate in this respect. Pattern, however, is the only character which could be found to separate the two forms. Careful analysis of body proportions (including relative length of head, limbs, and tail with respect to length of body) produced negative results, and no discontinuity in size was apparent. Certain scale characters subject to variation have been compared in Table II for 11 *Eumeces taylori* and 11 *multivirgatus* from the Guadalupe Mountains. No difference in scalation between the two forms is evident.

The fact that these two types are so similar in every respect except pattern strongly suggests that the striped and unstriped forms actually represent two distinct pattern phases of a single species. Through a most fortunate circumstance it was possible to obtain conclusive evidence on this point. On Apirl 28, 1954, while collecting at 8000 feet in the Transition Zone forest at the southern end of the Guadalupe Mountains, an adult female *taylori* was found under the same rock with a large *multivirgatus* male. This was an unlikely coincidence for two separate species, considering the scarcity of individuals of both forms. The female proved to be gravid, and was isolated in a terrarium. On May 30 she laid five eggs, which were deposited in an excavation in the soil beneath a stone. The eggs were kept on slightly moist soil in a covered glass dish, and all hatched on June 28, 1954. Total lengths and tail lengths for the young immediately after hatching were, respectively, 61.3-33.8, 61.6-34.1, 62.6-34.8, 63.9-36.6, 65.2-37.8 mm.

Two distinct pattern types are represented in the brood. Two of the young agree in all essentials with the description already given of young *Eumeces multivirgatus* from the same area. The ground color of the head and back is brown. A light brown or tan, clearly defined, middorsal stripe runs along the back on adjacent halves of the two middorsal scale rows, fading out on the nape, but becoming visible again as an indistinct fork on the top of the head. A light cream dorsolateral line, much more vivid than the middorsal stripe, runs along the third scale row, and extends forward over the eye. A lateral light line of the same color extends back from the ear over the forearm and continues faintly along the side of the body. Longitudinal black lines, only faintly visible because of the dark ground color, border the middorsal stripe and the dorsolateral light lines. A broad dark band occupies the side between the dorsolateral and lateral light lines. The other three young are distinctly different in appearance, and apparently correspond to *Eumeces taylori*. The head and body are brown dorsally. A somewhat darker brown band is indistinctly present on the sides. The scales on the dorsum are darker in the areas of overlap with adjacent scales, giving the animal an indistinct and finely spotted appearance. There are no longitudinal stripes or lines as in the other pattern type. A pale brown streak extends over the eye, back over the shoulder, and dwindles away on the anterior portion of the body. On the neck this light marking is quite diffuse, and extends over the second, third, and fourth scale rows. On the anterior portion of the body it is restricted to the third scale row. Although this pale streak may correspond to the dorsolateral light line of the striped pattern, it is expressed differently. In the striped (*multivirgatus*) type it is a vivid and distinct cream colored line running the length of the body. In the unstriped (*taylori*) type it is a diffuse light brown mark on the head and thoracic region. The lips and throat are white, the belly a sooty grey, and the tail a brilliant blue in both pattern types.

The production of both striped and unstriped progeny by a typical *Eumeces taylori* female (this individual is illustrated on Plate I, A) furnishes conclusive proof that *Eumeces taylori* is not a valid species. It is obvious that the striped young correspond to the immature *Eumeces multivirgatus* (including what has been

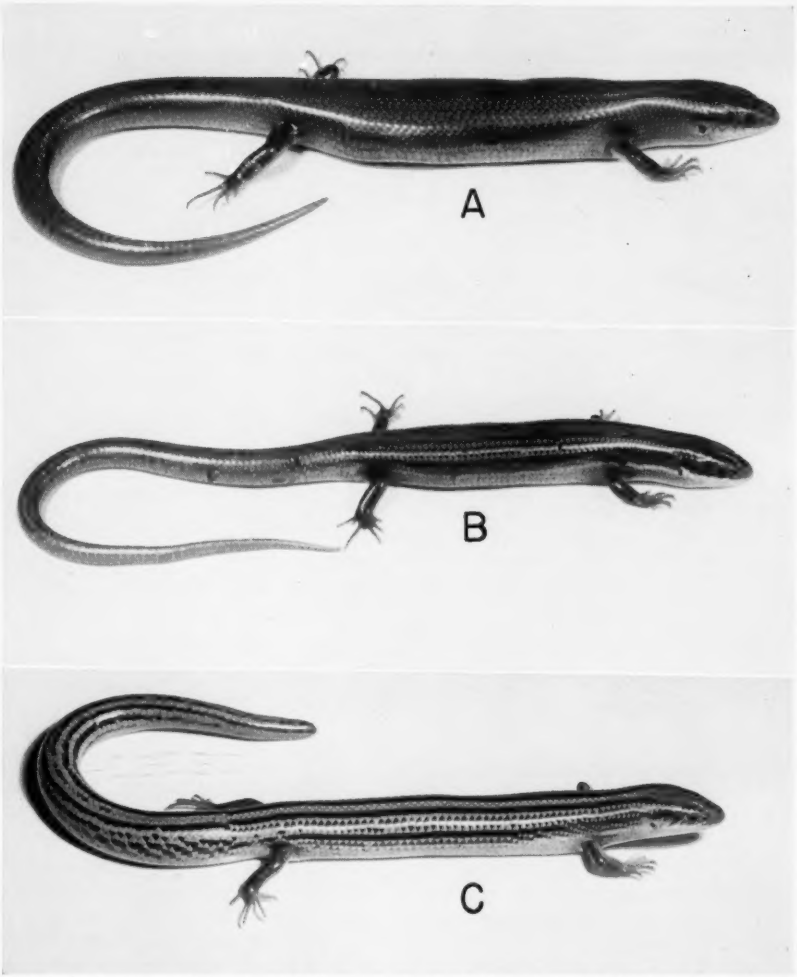

Plate I. A. *Eumeces multivirgatus*, adult female of the *taylori* phase, from the pine-fir-oak association at 8000 feet, Guadalupe Mountains. This is the parent of the mixed brood discussed in the text. B. *Eumeces multivirgatus*, young adult male of the striped phase, from the same locality as A. The dorsal dark lines have nearly disappeared in this individual. C. *Eumeces multivirgatus*, sex unknown, from sagebrush flats near Denver, Colorado. Photograph from the collection of Roger and Isabelle Conant.

TABLE I

ALTITUDES AND HABITATS FOR ALL KNOWN SPECIMENS OF TWO PATTERN PHASES OF *Eumeces multivirgatus* IN THE GUADALUPE MOUNTAIN REGION

Number of specimens		Altitude in feet	Locality	Habitat	Museum Numbers
striped phase	*taylori* phase				
11	2	7700–8200	The Bowl, near Pine Sprs., Culberson Co., Tex.	Transition Zone, pine-fir-oak	UMMZ 70518 TNHC 16289–91, 17993–18000, 20144
—	1	5700	Near Queen, Eddy Co., New Mexico	Upper Sonoran, pinon-juniper	TNHC 20145
1	1	5500	Frijole, Culberson Co., Tex.	Upper Sonoran, Oak-juniper, near spring	UMMZ 70516–17
—	1	5000 ?	Dark Canyon, Eddy Co., New Mexico	Upper Sonoran, canyon floor	UMMZ 70103
—	6	4800	Sitting Bull Canyon, Eddy Co. New Mexico	Upper Sonoran, canyon floor, along stream	TNHC 16233–35, 17992 UCLA 4616, 4618
—	1	3600	Black River, near Carlsbad Caverns, Eddy Co., New Mexico	Lower Sonoran, dry stream bed	UK 13161
—	1	3200	Two miles NW Carlsbad, Eddy Co., New Mexico	Lower Sonoran, along stream	UCMVZ 37007

called *gaigei*), and the unstriped young to immature *Eumeces taylori*. There is little basis for postulating hybridization between two distinct species. This would imply that the writer was fortunate enough to secure a gravid female which had mated in nature with a member of the other species. If such crossmatings were so frequent as to have been encountered in this particular instance, it is remarkable that the two "species" have maintained themselves as distinct entities in nature. To the contrary, all the known specimens are readily assignable to striped (*multivirgatus*) and unstriped (*taylori*) phases, with no intermediate individuals. Furthermore, the five young hatched in the laboratory fall into two distinct classes, with no trace of intermediacy and with perfect agreement within the two respective types. Differences between species are usually of a polygenic nature which produce intermediate characteristics in the hybrids, rather than discontinuous classes as in the present case.

Sexual dimorphism is not a factor, as each sex is represented by both pattern types. The available evidence, therefore, points to a fairly simple alternate, allelic type of inheritance, and *Eumeces taylori* must be regarded as nothing but an allelomorphic pattern phase of *Eumeces multivirgatus*. The striped male found with the parent female was probably the father of the offspring. If this was actually the case, then one of the parents must have been homozygous and the other heterozygous for the factors producing the striped and unstriped pattern types. The data, however, do not indicate which factor is dominant.

The distribution of the two phases with respect to altitude is of interest. In Table I altitudes and habitats have been summarized for all the striped (*multivirgatus*) and unstriped (*taylori*) skinks of this group known from the Guadalupe Mountain region. All the striped specimens with the exception of one came from altitudes of 7700 feet or above in the Transition Zone. The majority of the *taylori* came

TABLE II

SUMMARY OF SCALE CHARACTERS FOR THREE SAMPLES OF *Eumeces multivirgatus*

The Guadalupe Mountain series has been separated into striped and unstriped phases in order to emphasize the lack of difference between the two types.

	Weld and Adams Cos., Colorado	San Miguel Co. New Mex.,	Striped phase Guadalupe Mts.	*Taylori* phase Guadalupe Mts.
	Number of specimens			
	34	7	11	11
Scales around body				
23	—	2	—	—
24	14	5	5	7
25	5	—	2	—
26	15	—	4	4
Dorsals				
Mean	60.0	56.7	59.5	59.8
Range	58–62	53–59	57–61	58–62
Postnasals				
Present both sides	29	3	8	9
Absent one side	4	2	2	—
Absent both sides	1	2	1	2
Upper labials				
7 both sides	33	7	10	11
6 one side	1	—	1	—

from much lower altitudes, indicating a partial ecological separation of the two pattern types. The distribution suggests that the factor determining the patternless phenotype is of superior selective value in the lower, more xeric habitats. This hypothesis is supported by the southern location of other records of the *taylori* phase, most of which fall in Lower Sonoran situations (Fig. 2).

GEOGRAPHIC VARIATION

Demonstration that neither *Eumeces taylori* nor *Eumeces gaigei* are separable from *Eumeces multivirgatus* as distinct species raises a question as to the nature of geographic variation in *Eumeces multivirgatus*. Variation of a consistent and concordant nature might necessitate the retention of *taylori* or *gaigei* as subspecies. In an attempt to clarify the problem, various characters of possible taxonomic significance have been analyzed independently.

SIZE.—No obvious geographic differences were apparent in the available material. The two largest specimens examined, both measuring 71.2 mm. snout-vent, came from opposite extremes of the range (Catron County, New Mexico, and Weld County, Colorado). Most adult examples are below 65 mm. in all portions of the range. There was no evidence of sexual dimorphism in size.

PROPORTIONS.—Analysis of head and leg length relative to body length produced negative results, possibly because of the difficulty of measuring these two extremities accurately. Tail length relative to body length showed significant geographic variation, although the great majority of available specimens have broken or regenerated tails, thereby limiting the value of this character. Most of the specimens with complete tails came from the Guadalupe Mountains and north central Colorado (Weld, Adams, and El Paso counties). The ratios of tail to body for these two samples, together with those of three examples from Nebraska, the Pecos County, Texas, specimen, and single specimens from Rio Arriba and San Miguel counties, New Mexico, have been plotted against body length in a scatter diagram (Fig. 1). All the Guadalupe Mountain specimens fall above the Colorado and Nebraska samples. Close agreement is apparent between the latter two groups, as would be expected on the basis of their close geographic relationship. The two examples from

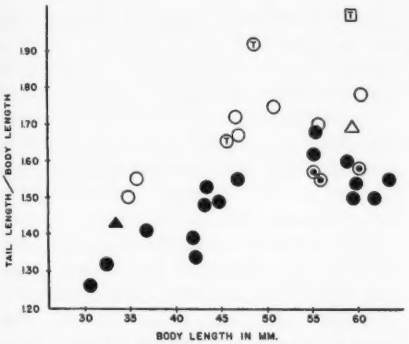

Fig. 1. Ratio of tail length to body length plotted against body length for specimens of *Eumeces multivirgatus*. Examples from Weld, Adams, and El Paso counties, Colorado, represented by black circles; western Nebraska by circles with black centers; black triangle, San Miguel County, New Mexico; light triangle, Rio Arriba County, New Mexico. Guadalupe Mountain (Culberson County, Texas; Eddy County, New Mexico) material represented by light circles; the light square is an example from Pecos County, Texas. Specimens of the *taylori* phase indicated by a T.

Fig. 2. Distribution of pattern types in *Eumeces multivirgatus*, based on specimens examined by the writer. Plain circles indicate a pale body color with heavy, clearly defined dorsal dark lines on adjacent portions of the first and second scale rows. Double circles indicate a brown body color, with strongly contrasting dorsolateral light stripes, and variable reduction of the dorsal dark lines. A bar on the symbol indicates that extreme reduction or loss of the dorsal dark line has been observed. Black symbols indicate the patternless *taylori* phase. The dark centered circle on the Texas-New Mexico border indicates the presence of both *taylori* and striped phases. Crosses represent literature records, although the map is not complete in this respect.

northern New Mexico (Rio Arriba and San Miguel counties) seem to fall between the Guadalupe Mountain and Colorado plus Nebraska material, but little reliance can be placed on only two specimens. The longest tail relative to body is exhibited by the specimen (*taylori* phase) from Pecos County, Texas, the southernmost locality.

On the basis of these few specimens it can therefore be concluded that individuals from the southernmost portion of the range (western Texas, southern New Mexico) have relatively longer tails than those from Colorado and Nebraska. It is not certain, however, whether the change in tail length from north to south is abrupt, clinal, or irregular. The two specimens from northern New Mexico indicate that it may be clinal.

SCALATION.—The number of scales around the middle of the body, the dorsal scale count, presence or absence of postnasals, and number of upper labials are given in Table II for 22 specimens from the Guadalupe Mountains, seven specimens from San Miguel County, New Mexico, and 34 specimens from Weld and Adams counties, Colorado. These are the only localities from which fairly adequate samples were available. The Guadalupe series has been divided into *taylori* and striped classes to emphasize the lack of difference between the two types. There is remarkably close agreement in all four characters between the Guadalupe and Colorado samples, and any slight difference between them would have to be demonstrated by much larger series. The San Miguel sample shows indications of a lower number of scales around the body, and a lower number of dorsals, but is apparently somewhat abberant in this respect. Scalation was examined in 97 specimens from various portions of the range, and this was the only area where specimens with less than 24 scales around the body and less than 56 dorsals were encountered. All other specimens (see Fig. 2 for localities) fall within the range of variation of the Guadalupe Mountain and Colorado series for these four characters with a few minor exceptions. One specimen from McKinley County, New Mexico,

has only 57 dorsals, and two from Otero County, New Mexico, have 56 and 57 dorsals, respectively. Single specimens were examined from Chaves County, New Mexico, and south of Walsenburg, Colorado (Las Animas or Huerfano County), with eight upper labials on one side. All other specimens not in the table have seven upper labials on both sides with the exception of one specimen from Sioux County, Nebraska, with six on one side, and a specimen from Bernalillo County, New Mexico, with six on both sides. This last mentioned specimen (UCLA 4620) is unusual in that it shows a definite tendency for overall fusion of head scales, reflected in fusion of the sixth and seventh upper labials, absence of the postnasal on both sides, and fusion of the two postmentals into a single scale. Fusion of the postmentals is rare, and was observed in only four other specimens (from Culberson County, Texas; Niobrara County, Wyoming; Weld County, Colorado; and San Miguel County, New Mexico, respectively).

Other scale characters which have been mentioned in past descriptions are enclosure of the interparietal posteriorly by the parietals and contact of the prefrontals. The interparietal is enclosed posteriorly by the parietal in only six of the specimens examined. Four of these came from Arizona (out of five specimens examined from that state), another from Grant County New Mexico, and the other from Pecos County, Texas. Apparently, therefore, enclosure of the interparietal is more common in the western portion of the range, but is not restricted to that area. The prefrontals are in contact in 87.2 percent of the Colorado and Nebraska specimens, as contrasted with only 31.6 percent in the Guadalupe series. Seven out of nine specimens from north-central New Mexico (Rio Arriba, Sandoval, and San Miguel counties) have these scales in contact, as compared with seven out of eight from western New Mexico (McKinley, Catron, and Grant counties), and two out of five from Arizona. It seems probable, therefore, that the degree of contact of the prefrontals in northern and western New Mexico is more comparable with Colorado and Nebraska populations than with the Guadalupe series.

To summarize these somewhat meager data, it appears that there is little or no consistent geographic variation in scale characters. The few geographic trends indicated are of a markly discordant type. Thus, Colorado and Nebraska specimens seem to agree closely with southern New Mexico (Guadalupe Mountains) material in number of dorsals and body scale rows and frequency of enclosure of the interparietal, but differ in percent of prefrontal contact. Western New Mexico material agrees with both the Guadalupe Mountains and Colorado plus Nebraska series with respect to dorsals, body scale rows, and interparietal enclosure, but falls closer to the Colorado plus Nebraska sample in prefrontal contact, as does the San Miguel County (north-central New Mexico) material. However, the latter sample exhibits an unusually low dorsal and body scale row count. The few Arizona examples show no unusual deviation in number of dorsals and body scale rows, but have the interparietal enclosed with unusually high frequency. Other scattered specimens (such as the Bernalillo County example) may show marked deviation from the modal type of scalation, leading to the conclusion that local, rather than geographic trends are of importance in scale characters, particularly in the southern and western portion of the range.

PATTERN.—Marked variation in two outstanding elements of the pattern exists between certain areas, and inadequate analysis of this variation has been responsible for much of the confused taxonomy relating to this species. These two pattern elements are: 1. intensity of ground color, variation in which greatly influences the contrast of the dark and light longitudinal stripes and lines; 2. the dark dorsal line on adjacent portions of the first and second scale rows, subject to variation in width and definition. Extreme reduction of this line in certain specimens from New Mexico led to the description of *Eumeces gaigei*.

Specimens from Colorado and Nebraska are strikingly pale in dorsal ground color, as compared with well preserved, alcoholic specimens from New Mexico and Arizona. This pale body color produces great contrast of the longitudinal dark lines and a loss of the dorsolateral light line (at least in preservative) as a distinct part of the pattern. The result is a pattern of alternating light and dark stripes or lines which is quite distinctive in appearance

(see Figs. C, D, and E, Pl. 101, Smith 1946, and Pl. I, C, this paper). All specimens from New Mexico and the few Arizona examples examined are readily distinguishable from Colorado and Nebraska specimens on the basis of their darker, brown body color. This dark color tends to obscure the dark lines, and causes the light dorsolateral line on the third scale row to become a prominent part of the pattern, as well as the light middorsal stripe in young individuals.

Smith (1946) states that the light middorsal stripe is not present in the young of "eastern" (presumably Colorado and Nebraska) specimens, but this is not precisely correct. In very young and well preserved examples examined from these areas, the body color is somewhat darker than in the adult, and middorsal, dorsolateral, and lateral light stripes are very faintly distinguishable. However, these stripes are lost as distinct elements (as opposed to ground color) in preserved material because of rapid lightening of body color with increase in size. On the other hand, immature specimens available from San Miguel, Grant, and Catron counties, New Mexico, and Coconino County, Arizona, all have boldly contrasting middorsal light stripes, and young adults from this region may still show slight traces of the stripe anteriorly. Young examples of the striped phase in the Guadalupe Mountain region also have well defined middorsal light stripes, although this marking does not appear to be as contrasting as in the above mentioned specimens.

Colorado and Nebraska material can also be distinguished from specimens from other portions of the range on the basis of the dark dorsal line on adjacent portions of the first and second scale rows. In specimens from this area the line is usually broad, occupying as much as adjacent halves of the two scale rows, is clearly defined, with continuous, uninterrupted margins, and is not subject to reduction with age. In New Mexico material at least, the line is of variable width, is not as clearly defined, and invasion of ground color from the sides may leave most of the dark pigment concentrated on adjacent portions of the posterior margins of the first and second scale rows. In many specimens this lends a somewhat zig-zag or broken appearance to the line, which then runs along the point of juncture of the two scale rows. In adults in some areas the line may completely disappear, giving a *gaigei* type of pattern.

As already indicated, the Guadalupe Mountain material shows a fairly uniform reduction of the dorsal dark line with age, and large adults may have this line completely absent. This reduction does not appear to take place consistently, however, in some other populations in New Mexico. In a series of five adults (all over 55 mm. snout-vent) from San Miguel County, none has completely lost this line, although a varying amount of reduction is exhibited. The largest individual (59.5 mm.) has the dorsal lines reduced to a narrow but distinct marking on adjacent parts of the first and second scale rows. Of two adults (60.4 and 60.2 mm.) from McKinley County, one has very narrow dorsal dark lines, while in the other specimen the lines are somewhat wider. An adult (65.6 mm.) from Grant County has reduced but clearly defined dorsal dark lines, while these markings have been almost lost in another specimen (68.0 mm.) from the same locality. The unusually large specimen (UCM 6128) from Catron County has heavy dorsal dark lines with no reduction in width of the lines. An adult from Sandoval County has these lines considerably reduced in width, but still clearly visible. Complete loss of the dorsal dark lines was observed in two adults (59.6 and 60.1 mm.) from Otero County and in the paratype of *Eumeces gaigei* from Taos. Material from Arizona was inadequate for evaluation of this character. However, single adults from Greenlee, Apache, and Mohave counties, respectively, all have well developed dorsal dark lines on the first and second scale rows with at least some invasion of the ground color on the sides of the lines.

The reduced pattern of the *taylori* phase is not directly comparable with the variation discussed above, as it does not involve a modification of the basic striped pattern but rather an obliteration of it. Little variation was noted among the specimens of this type, and most examples examined agreed closely with the Guadalupe series. A partial exception is the specimen from near Roswell, Chaves County, reported on by Neess, Budny, and Meyer. This example exhibits very indistinct longitudinal dark lines where the scale rows overlap. Mark-

ing of this type is very faintly indicated in some of the other specimens of this phase, particularly in UCMVZ 49839 from 2 miles west of Roswell, but is not as apparent as in the above mentioned specimen. This faint pattern, however, seems to be in no way homologous with the striped pattern of the alternate phase. A more puzzling specimen is UCLA 4620 from Bernalillo County, New Mexico, already mentioned with respect to its abberant scalation. The pattern here is of the *taylori* type, but there are the faintest indications of a lateral light line extending from behind the ear to just past the forearm, and an exceedingly fine light line runs down the middle of the third scale row from shortly behind the head to just over the forearm, disappearing on the body. It seems probable that the fine line in the shoulder region is a vestige of the light streak which was found to occur in newly hatched young from the Guadalupe Mountains assigned to this phase. However, faint traces of a lateral line in this particular specimen cannot be explained on the basis of juvenile characteristics of the *taylori* type, and it is possible that the simple two phase hypothesis may be considerably complicated over a wide geographic range by modifying genetic factors in different populations.

The distribution of the various pattern types has been indicated on the map, Fig. 2.

Conclusions

The range of *Eumeces multivirgatus* (including *Eumeces gaigei* and *taylori*) consists of two major geographic divisions. One of these includes most of the state of New Mexico, western Texas, probably adjacent parts of the Chihuahuan desert in northern Mexico, and the plateau area of northern Arizona. The other division includes the Colorado piedmont of northern and central Colorado at the eastern base of the Rocky Mountains, the sand hill and prairie region of western Nebraska and northeastern Colorado, and adjacent portions of Wyoming and South Dakota. This latter geographic segment of the species is peninsular in form, being only narrowly connected in south-central Colorado with the remainder of the range, and is therefore partly isolated from populations in New Mexico, western Texas, and Arizona.

Our knowledge of the ecology of the species is very incomplete. However, there are indications that considerable differences exist in habitat between different parts of the range. The sand hill and prairie region of western Nebraska and northern and central Colorado offers a relatively undiversified environment; skinks inhabiting this area probably exhibit a fairly uniform type of ecology. Locality records indicate that the species is more or less confined to grassland areas at altitudes below 5500 feet, and does not penetrate the mountains. Hudson (1942) mentions the collecting of specimens under dried cow chips on a grassy hillside near Agate, Nebraska, and Taylor (1936) quotes an account by Barry of specimens being found under identical cover in a prairie-dog town in Weld County, Colorado. According to Barry the species is common in vacant lots in Denver. In the portion of the range in western Texas, New Mexico, and Arizona, however, the species inhabits a surprising variety of habitats, ranging from high mountains and plateaus to creosote bush desert. This is exemplified by local distribution in the Guadalupe Mountain region where the form has been recorded from 3200 feet in the Lower Sonoran Zone to 8200 feet in the Transition Zone. The habitats represented by the specimens available from this area have already been indicated in Table I. Sparse data also indicate a considerable variation in habitat in other localities in the southern and western portion of the range. Neess, Bundy, and Meyer (in press) took a specimen of the *taylori* phase in heavy grass in an area of generally more open mesquite-creosote bush desert near Roswell, New Mexico. Taylor (1935) collected specimens under rocks on a barren hillside near Taos. Some indications of altitude and habitat on museum tags of specimens examined from New Mexico are: San Miguel County, 7200, 8000 feet; Catron County, 7200 feet; Otero County, in yellow pine and scrub oak association on southwestern talus slope, 6900 feet. As already mentioned, most of the specimens of the *taylori* type (aside from the Guadalupe Mountain material) come from localities which almost certainly fall in the lower Sonoran Zone (a possible exception is UCLA 4620 from the Sandia Mountains, New Mexico), while locali-

ties represented by the striped phase appear to fall in Upper Sonoran or Transition Zones.

Information on distribution and ecology seem to be in accord with the pattern of geographic variation. A consistent and distinctive pattern was found in the Colorado and Nebraska material, which is uniformly characterized by a pale body color with dorsolateral light stripes only slightly lighter than the ground color, and a broad, clearly defined dorsal dark line (with uninterrupted margins) on adjacent portions of the first and second scale rows. Specimens from this region are different in appearance from New Mexico, western Texas, and Arizona striped specimens, which are darker, have strongly contrasting dorsolateral light lines (with a contrasting middorsal light line in the young), and exhibit a variable degree of reduction of the dorsal dark lines through invasion of ground color from the sides. Moreover, a considerable degree of variation was noted in the southern and western portion of the range. Particularly obvious in this respect is the existence of two pattern types (*taylori* and striped) in New Mexico and western Texas, but variation is also shown in the amount of reduction of the dorsal dark lines in the striped phase, and in scalation. In both these latter characters local, rather than geographic, trends seem to be of importance. This type of variation is consistent with the considerable range of habitats occupied by the species in this portion of the range. Although the ability of the species to occupy a variety of habitats may tend to minimize the amount of geographic isolation of any particular population, many populations would be subject to a considerable degree of genetic isolation because of different adaptive values for certain characters in different environments. Selection pressures may differ tremendously between Transition Zone forest and Lower Sonoran desert, and populations occupying high mountains and plateaus would be subject to considerable independent evolution, even though the species might also occupy intermediate lower habitats. The possession of two distinct pattern phases in the southern portion of the range where the divergence in habitats is probably most extreme (mountain and basin topography) might be regarded as an adaptive "short cut" for the species, aiding it in the occupation of very different habitats in the same region.

It is apparent from the foregoing analysis that *Eumeces multivirgatus* is divisible into two fairly natural units on the basis of distribution and character variation. One of these units (Colorado, Nebraska) shows a high degree of consistency in its characters. The other (western Texas, New Mexico, Arizona) is quite variable. In spite of the fact that application of a single subspecific name to populations of the latter area implies a uniformity which does not exist, it is necessary to recognize the marked discontinuity with Colorado and Nebraska material. I therefore suggest that populations of central and northern Colorado, Nebraska, and Wyoming be designated as *Eumeces multivirgatus multivirgatus* (Hallowell) and western Texas, New Mexico, and Arizona material be called *Eumeces multivirgatus gaigei* Taylor.

There is no reason for retaining the name *taylori*. Specimens exhibiting the *taylori* type of pattern are distinctive in appearance and possibly occur to the relative exclusion of striped examples at lower altitudes in the southernmost portion of the range. However, this type is only a pattern phase determined by one or a very few genes, it occurs sympatrically with the striped phase in the Guadalupe Mountains, and is not supported by differences in other characters. Therefore, it does not correspond to the subspecies as a natural biological unit.

An obvious question which might arise is whether the Colorado and Nebraska populations may actually be specifically distinct from more southern and western material. As no intermediate specimens have been examined, this possibility cannot be positively eliminated. Maslin (1950) reported single specimens from Alamosa and Costilla counties in southern Colorado. It was stated that these examples were similar to the plains (eastern Colorado) form but differed in ecology, both being found between large boulders in rocky areas above 8000 feet. Maslin concluded on ecological and geographical grounds that these records represent a tongue of the Arizona-New Mexico population extending into the San Luis Valley. These two specimens have not been examined, but an example (UMMZ 62236) labeled simply as south of Walsenburg, Colorado (presumably

Las Animas or Huerfano county), shows no approach to the typical Colorado pattern. The coloration is brown, and the dorsal dark lines are reduced to markings on adjacent portions of the posterior margins of the scales of the first and second rows. Certainly the geographical relationship of the two races of *Eumeces multivirgatus* is such as would be conducive to genetic divergence through partial isolation, perhaps even to the species level. Nevertheless, in view of the obviously close relationship of the two forms and their continguous although allopatric distribution, it is more reasonable to treat them as members of the same species.

Summary

New material collected in the Guadalupe Mountains of western Texas and southern New Mexico made it apparent that neither *Eumeces gaigei* nor *Eumeces taylori* are separable as valid species from *Eumeces multivirgatus*. Recognition of *Eumeces gaigei* as a distinct species is shown to have been the result of confusion caused by ontogenetic pattern change. *Eumeces taylori* is demonstrated to be an allelomorphic pattern variant. Ecological distribution of the striped and unstriped (*taylori*) phases in New Mexico and western Texas indicates that the unstriped phase may be of superior selective value in the lower and more xeric habitats.

An analysis of geographic variation revealed that *Eumeces multivirgatus* is composed of two major geographic and morphological subdivsions. The more northern of these occupies the sandhill and prairie region of eastern Colorado, western Nebraska, and southeastern Wyoming. Populations in this region seem to have a fairly uniform ecology and exhibit little variation in characters. The other subdivision of the species occupies western Texas, New Mexico, and northern Arizona. In this region the species occupies a wide range of habitats, and is morphologically much more variable. In order to emphasize the discontinuity between the northern and southern segments of the species, it is suggested that they be recognized as subspecies—populations of central and northern Colorado, Nebraska, and Wyoming as *Eumeces multivirgatus multivirgatus* (Hallowell), and those of western Texas, New Mexico, and Arizona as *Eumeces multivirgatus gaigei* Taylor. The ecological and geographical relationships of these two races are such that each may actually represent an incipient species.

Specimens Examined

Eumeces multivirgatus multivirgatus Hallowell

Colorado: Adams Co., UCM 5702–05; Denver Co., EHT-HMS A850–55; El Paso Co., AMNH 57698–99; Larimer Co., UCM 224; Weld Co., UCM 225, 729, 1066, 2332–36, 2847, 3122–25, 3418–26, 5556–60, 5596–606, 5696–701, 6701–07, UMMZ 74444, UCMVZ 49840, USNM 27741; Indefinite Locality, ANSP 13533.

Nebraska: Brown Co., USNM 28367–68; Cherry Co., UMMZ 74717, 74728, UCMVZ 18265; Scotts Bluff Co., AMNH 67853; Sioux Co., AMNH 64144–45, 32382; Indefinite Locality, USNM 3180(10), 4139(7), 9264, AMNH 1250–51.

Wyoming: Niobrara Co., AMNH 73038; Indefinite Locality, USNM 9230.

Eumeces multivirgatus gaigei Taylor

Specimens of the *taylori* phase have been indicated by (T).

Arizona: Apache Co., USNM 11459, CNHM 44921; Coconino Co., UMMZ 79206(2); Greenlee Co., UA 317; Mohave Co., CNHM 94827.

Colorado: Las Animas or Huerfano Co., UMMZ 62238.

New Mexico: Bernalillo Co., UCLA 4620(T); Catron Co., UCM 6128, UCLA 3600; Chaves Co., UCMVZ 49839(T); Eddy Co., UMMZ 70103(T), KU 13161(T), UCMVZ 37007(T), UCLA 4616(T), 4618(T), TNHC 16233–35(T), 17992(T), 20145(T); Grant Co., ANSP 20819–21; McKinley Co., USNM 16015–17; Otero Co., UCLA 3601, 4627; Rio Arriba Co., UC MVZ 25223; San Miguel Co., UMMZ 53401, CNHM 57319–22, UCLA 4622, 4625; Sandoval Co., UCMVZ 22396; Taos Co., KU 7301; Indefinite Locality, USNM 38507, AMNH 38369–70.

Texas: Culberson Co., UMMZ 70516(T), 70517–18, TNHC 16289–91, 17993(T), 17994–99, 18000(T), 20144; Pecos Co., UMMZ 105126(T).

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DEPARTMENT OF ZOOLOGY-ENTOMOLOGY, ALABAMA POLYTECHNIC INSTITUTE, AUBURN, ALABAMA.

Observations on the Behavior of Blind and Blinded Fishes[1]

KENNETH R. JOHN

IN avoiding collisions with stationary structures in their environment, do blind fishes depend on the reception of cues that reveal the presence of the structures, or do they remember the location of the structures at the expense of some amount of tactile experience? The literature yields conflicting conclusions. Even with regard to the single blind genus *Anoptichthys*, one finds (Hubbs and Innes, 1936; Breder, 1943; and Lüling, 1954) two fundamental views: (1) that the fish avoid stationary objects with the aid of distance perception and (2) that the fish locate objects by trial and error, and after a certain period of exposure, learn to avoid them.

In the present attempt to clarify the understanding on this type of orientation, an analysis was made of the various components of orientation, including memory and distance perception. Additional inquiries were made concerning the adaptive value of effective nonvisual orientation.

In this paper, the term blind designates an inherited loss of vision, and blinded implies a mechanical loss at the hands of the investigator. In these studies memory is used only in connection with tactile experience. In contrast, distance perception means detecting an object without contact, and so far as the detection of objects alone is concerned, distance perception is not dependent on memory. Thus, in blind and blinded fishes, memory and distance perception are the alternate sensory mechanisms employed in spatial orientation. Unless it is specified otherwise, the results pertain only to blind or blinded fish.

MATERIALS AND METHODS

Most of the results were obtained on *Anoptichthys hubbsi* (Alvarez) and *Astyanax mexicanus* (Filippi), a close relative and probable ancestor of *Anoptichthys*. *Anoptichthys* is genetically blind; all other species were blinded either by sectioning the optic nerve or by removing the eyes. Generally, in preparation for surgery, the fish were anesthetized in urethane.

Two procedures were used in testing the ability of the fishes to avoid an unfamiliar solid-surfaced obstacle: (1) the fish were transferred to an aquarium in which an obstacle had been previously erected; (2) a similar obstacle was inserted carefully into an aquarium in which the fish had resided for a day or so. With *Anoptichthys* and *Astyanax*, cinematographs were taken as the fish approached the obstacle because it was otherwise impossible to be certain whether or not the fish established contact with the obstacle. Larger species of fishes did not present this problem; their reactions could be determined accurately with

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the unaided eye. It was important to record the results of the fish's first approaches toward the obstacle because only then could one disregard the possibility that their reactions were influenced by memory of previous encounters.

The ability of the fishes to remember the location of an object was tested with the aid of an obstacle that delivered punishment to the fish upon contact and that was presumably undetectable by the fish except through direct contact. The obstacle was a piece of ¼ inch lucite, 3 inches wide and 5 inches long, with No. 3 insect pins mounted perpendicularly on one side, the points projecting outward. Spaced rather uniformly, the pins were sufficiently close to prevent the fish from entering between adjacent rows without hitting the points. Standing on its end in the aquarium, this pin-studded obstacle presented the fish with one solid smooth surface and one composed of pin points. With the obstacle in place, the fish was given several days to adjust to the aquarium. Then, its boundaries having been marked on the side of the aquarium, the obstacle was removed and a record was made of the behavior of the fish toward the site that the obstacle had occupied.

Using the pin-studded obstacle, a measure was obtained of the time required by the fish to learn the object's position. Individual fish were transferred to an aquarium housing the obstacle and their frequency of approaches and collisions recorded chronologically to find the time required to attain maximum effectiveness in avoiding the obstacle.

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These studies were carried out in the laboratory of the Department of Fishes and Aquatic Biology of the American Museum of Natural History and at the Lerner Marine Laboratory, Bimini, B. W. I.

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Results

General Observations.—The reactions of *Anoptichthys* toward stationary obstacles in 1′ x 1′ x 2′ aquaria were quite variable. When the fish swam rapidly toward a vertical wall, it was frequently impossible to be certain, by direct observation, whether or not they had established contact with the wall before turning away from it. For the most part, they swam about rather actively and continuously, usually following the periphery of the aquarium.

Whether or not the fish established contact with a solid surface in their path appeared to relate to their activities as they approached it. Sometimes the fish approached a vertical surface as they foraged, as though feeding, along the bottom, or as they rubbed along the side of the aquarium. Generally, in this type of approach, upon encountering the vertical surface, they established contact with it; frequently they continued to forage on it. At other times, the fish approached the vertical surface directly, on a course above the bottom and away from the sides of the aquarium. In this type of approach, they usually turned before touching the surface. Rarely did the fish strike a solid surface head-on with sufficient impact to suggest that they had collided, and rarely did they appear to be frightened upon encountering a strange obstacle in their path. There were occasions when the fish did appear to be frightened upon encountering an object, but it is noteworthy that such response was elicited not only with regard to strange objects, but also with those that the fish had been exposed to for a long time. In general, the fish exhibited no persistent tendency to avoid contact with either strange or familiar surfaces.

Response to Sounds.—The fish under observation were often less active in the morning before the daily activities in the museum began than during the remainder of the day. Were the fish responding to noises produced by human activities? If so, might they not also orient to ambient sounds in their environment? Experiments were undertaken to find out whether or not the fish would orient to sounds. Four immature *Anoptichthys*, about 50 mm.

total length, were placed in an aquarium 1′ x 1′ x 2′ that was divided into two equal one-foot square chambers by a central partition of tile slabs. A central passageway about 2 inches wide and 5 inches high, the depth of the water, enabled the fish to move from one chamber to the other. The bottom was covered by sand, and aquatic plants were placed in both partitions. A beaker, about 6 inches high—one inch greater than the depth of the water—was placed in one of the far corners of each chamber. The beakers were filled with water to about the five inch level, and a sandstone aeration nozzle was placed in each beaker. Air was admitted to only one beaker at any time. Turbulence was not induced in the water of the aquarium.

The fish predominantly occupied the chamber housing the active aerator, and remained almost motionless in the near vicinity of the beaker for prolonged periods. When the air supply was turned off, they immediately began to swim in a wandering manner. They could be drawn alternately from one chamber to the other by turning off one air supply and turning on the other. However, they did not make the change directly and immediately, at least not as a group. Several minutes passed each time before they had all moved to the chamber with the active aerator, but the intensity of their response diminished within 3 or 4 days. It could be reactivated by exposing them for a time to the aerator placed in the water of the aquarium, not in the beaker, and then returning it to the beaker. This behavior suggested that they were not attracted by the noise or sounds as such but rather were attracted by sounds associated with the circulation or aeration induced by the nozzle. The tests were repeated on eight younger *Anoptichthys*, about 30 mm. in total length, that had not had previous exposure with an aeration nozzle, or other aeration device in the aquaria of the museum. (One cannot assume that they had not been exposed to such aeration at the Tampa Nurseries, from which they were obtained). These young fish exhibited a similar tendency to remain quietly in the chamber housing the active aerator. The force of this attraction to the fish was suggested by their tendency to jump up an inch to gain access to the beaker. Upon arriving in the laboratory in the morning, on two occasions, during a five-day period, a single fish was found inside the beaker.

It seems clear that the fish do orient to sounds, but further work is necessary to find out whether or not their orientation to sounds depends on previous conditioning to other stimuli accompanied by sounds. There was no opportunity to repeat the experiments on fish that were known definitely to have had no previous exposure to aerators.

AVOIDANCE OF UNFAMILIAR SOLID SURFACES.—When transferred to an aquarium containing a solid glass barrier in place, or when a glass barrier was inserted into the aquarium housing an adjusted fish, both *Anoptichthys* and blinded *Astyanax* demonstrated some ability to avoid contact with a solid surface upon their first head-on approach toward it. However, the fishes did not invariably avoid head-on contact with the plate on

TABLE I

SUMMATION OF OBSERVATIONS ON REACTIONS OF SIGHTLESS FISHES TOWARD UNFAMILIAR VERTICAL GLASS SURFACE ON THEIR FIRST APPROACH

Reactions of subsequent approaches were noted on all fish except *Anoptichthys* 3. Each first approach means that the fish was transferred to a different aquarium. Table shows number of particular approaches and number of approaches that ended in contact with the surface. A × indicates that the fish established contact; a 0, no contact.

	Approaches					
	First	Second	Third	Fourth	Fifth	Sixth
Anoptichthys 1	0	×	0	0	0	0
Anoptichthys 2	0	0	0			
	0					
Anoptichthys 3	×					
	×					
	×					
	0					
	0					
	0					
Anoptichthys 4	×	0	0	0	0	0
Astyanax 1	0	0	0	0		
Astyanax 2	0	×	×			
	0	0	0			
	0	0				
	0	0				
	0					

their first approach, nor after a first avoidance, did they habitually avoid contact on subsequent approaches (Table I). Although the fish exhibited individual variation, most of them avoided contact rather consistently. Individual variations for tests in which the glass plate was inserted into the aquarium housing the test fish are shown in Table II. The number of consecutive observations having been large, the results show not only the variations in the reactions of initial approaches, but also show the variations in reactions of different fishes during cumulative experience.

TABLE II

REACTIONS OF 6 DIFFERENT *Anoptichthys* TOWARD A VERTICAL GLASS SURFACE INSERTED INTO AN AQUARIUM HOUSING A SINGLE FISH

Approaches toward the surface are listed in succession from number 1 onward. An × in the space indicates that fish established contact; 0 indicates that the fish avoided the surface. All avoidances were initiated at distances not exceeding about 4 mm. from the surface of the glass plate.

	Approach																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Anoptichthys A.....	0	×	0	0	0	0	0	×	0	0	0	×	×	×	×	×	0	×	×	×	End				
Anoptichthys B.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	×	0	0	0	0	×	0
Anoptichthys C.....	0	0	0	0	×	0	0	0	End																
Anoptichthys D.....	0	0	0	×	0	0	0	×	×	0	End														
Anoptichthys E.....	0	0	×	0	0	×	End																		
Anoptichthys F.....	0	0	0	0	0	0	0	×	0	0	End														

The irregularity in the reactions on first approaches did not necessarily signify that the fish had not detected the presence of the barrier. The fact that they rarely established contact with obvious impact implies that they had modified their approach in response to reception of mechanical cues as they approached the surface of the plate. It is noteworthy that in most tests, the fishes transferred to the experimental aquarium avoided contact with the plate on their first approach toward it. If the likelihood of a collision increases as a result of disturbing the fish, one would normally expect most collisions to occur on first approaches as a consequence of the disturbance in transferring the fish from one aquarium to another.

MEMORY OF SPATIAL RELATIONSHIPS.—The ability of the fish to remember the location of an object was determined on only one individual *Anoptichthys*. The test, which consisted of removing the pin-studded obstacle after the fish had become familiar with its location, was performed 4 times. This fish remained in the aquarium continuously throughout the series of tests. In the first test the obstacle was put in on December 3 and removed on December 6. After a lapse of 3 days, the obstacle was put in for the second test on December 9 and removed on December 15. After a lapse of 2 days the third test was run; the obstacle was put in on December 17 and removed on December 23. For the fourth test, the obstacle was put in on December 23 and removed on December 30. In a final test, a smooth flat glass plate was put in the aquarium on January 3 and removed on January 4 (1½ days).

In the first test, the obstacle was placed against the far side of the aquarium with the pins facing left. In the second test, the obstacle was placed against the near side with pins facing left. In the third test, the obstacle was on the near side with pins facing right and on the fourth test, the obstacle was on the near side with pins facing left. In the fifth test, a plain glass plate was inserted on the near side. Therefore, 4 days preceding the test using the flat glass, the fish had experienced an obstacle in that position with pin points facing left. Figure 1 shows the results of the second test; Figure 2 shows those of the fourth test.

The results of the first test are not graphed because the notes were too sketchy. The results of the third test are not reported because the test was filmed and the film was exhausted before the test ended. The point to be made is

that the fish had had experience with the pin-studded obstacle prior to making the record for Figure 1.

After the fish had learned the position of the pin-studded obstacle, it demonstrated two distinct patterns of behavior, one as it approached the smooth side, the other as it approached the side composed of pin points. It approached the smooth surface without any apparent change in its manner of swimming, then, when its snout had come within 4 mm. or less of the surface, it abruptly turned to avoid the surface and, without any other apparent change in its behavior, continued on its course along the periphery of the aquarium. Upon approaching the pin-studded surface, the fish almost consistently altered its manner of swimming from a regular undulatory pattern to a hesitant pattern, the latter accomplished by short, rapid strokes of the caudal fin, alternating with simultaneous extension of all paired fins. This change in the manner of approach commonly began when the fish came within 6 to 8 inches of the pin points and the hesitant manner persisted until 1) the fish swam into the points or 2) changed its course by 90° or 3) changed its course by 180°, in the latter two cases avoiding the points. The distance from the points at which the avoidance manuever was executed varied appreciably, often occurring when the fish was 6 to 8 inches away and occasionally when the snout came within a few millimeters of the points. The dominant pattern, avoidance at distances greater than an inch, combined with the occasional collision with the points suggested that the fish was capable of remembering only the approximate positions of the objects.

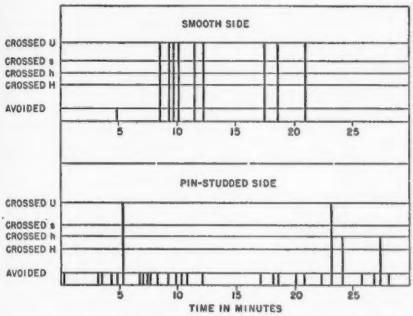

Fig. 1. Reactions of one *Anoptichthys* toward site formerly occupied by an obstacle that had one smooth side and one pin-studded side. Fish had 6 days to become familiar with location of obstacle. Obstacle was then removed and during the following half hour the time and direction of approaches and reactions were recorded. The degree of hesitation in each approach is indicated by the letters: U, unhesitant; S, slight; h, moderate; H strong hesitation.

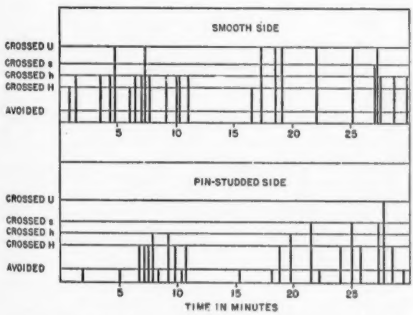

Fig. 2. Reactions of *Anoptichthys* (same fish as Figure 1) toward site formerly occupied by an obstacle that had one smooth side and one pin studded side. Fish had 7 days to become familiar with location of obstacle. Methods same as for Figure 1.

After the object was removed from the aquarium, the fish again demonstrated two distinct patterns of behavior (Fig. 1). Upon approaching the position formerly occupied by the smooth surface, excepting the first approach 4 minutes 50 seconds after removing the object, it showed no apparent change in its swimming pattern and proceeded unhesitatingly through the site. But, in approaching the site formerly composed of pin points, its approach became hesitant, the change commonly taking place at a distance as great as 6 to 8 inches from the site. Upon approaching the former site of pin points, the fish almost persistently performed an avoidance maneuver, even after it had once swum across the site at 5 minutes 10 seconds following the removal of the object. The avoidance was not precise. Usually the fish turned away at a distance greater than an inch from the points, but it often executed an abrupt avoidance after its snout had progressed beyond the former boundary of pin points, and occasionally after its snout had passed across both boundaries of the site.

The results indicate strongly that the fish was not able to detect the surface of pin points

from a distance but rather, in order to avoid them, depended on its memory of their position. Avoidances initiated at great distances and those occurring after the snout of the fish had progressed beyond the line again indicated that the fish's memory of spatial relationships was only approximate.

The second set of results (Fig. 2) are strictly comparable to those of Figure 1 only with regard to the question of whether or not the fish crossed the boundary lines marking the site formerly occupied by the object. The behavior was recorded in greater detail than it had been in Figure 1, giving an account of the manner of each approach.

The results in Figure 1 show that the fish appeared not to hesitate in approaching the site of the former smooth surface, but in subsequent tests the tendency to hesitate became noticeable regardless of the direction of the approach, as was shown during the fourth test (Fig. 2). The patterns of behavior still differed insofar as the fish frequently avoided the site formerly occupied by pin points but consistently crossed the site of the solid surface. It is noteworthy that the fish executed an abrupt close-range avoidance of the former site of pin points 29 minutes 30 seconds after the removal of the object and moreover after it had previously crossed the site 16 times.

The tendency of the fish to approach hesitantly toward the former sites of both the smooth and pin-studded sides of the obstacle (Fig. 2) suggested that the fish had learned to associate the two surfaces with the same object and had, upon removal of the object, become confused when it could no longer detect the smooth surface. Then, presumably because the fish had learned to associate punishment with undetectable surfaces it became hesitant in approaching the site formerly occupied by the smooth detectable surface because this was also the approximate site formerly occupied by the pin points. That such an association had possibly occurred is suggested in the results obtained on the same fish, using the same procedure, but substituting a smooth plate of glass in place of the pin-studded obstacle (Fig. 3). Having not been conditioned to receive punishment upon approaching the site from either direction and having been able to detect the presence of the obstacle in approaching from either direction, the fish passed through the site with little hesitation after the obstacle had been removed.

There is a noticeable difference in Figure 3 between the fish's behavior toward the left side

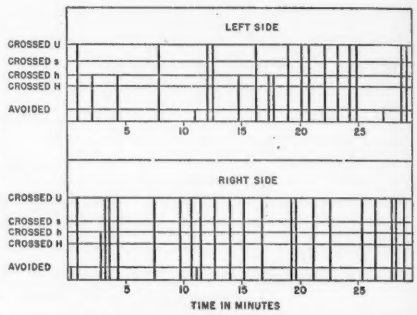

Fig. 3. Reactions of *Anoptichthys* (same fish as Figures 1 and 2) toward site formerly occupied by an obstacle that was smooth on both sides (a plate of glass). Fish had 32 hours to become familiar with location of obstacle. Methods same as for Figures 1 and 2.

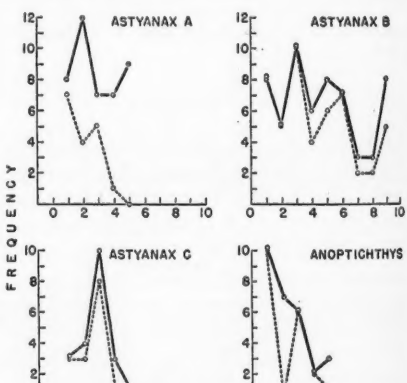

Fig. 4. Approaches and collisions into pin-studded surface during consecutive 5-minute intervals for *Anoptichthys* and blinded *Astyanax*. Fish tested individually by transferring them to aquarium housing obstacle. Tests were discontinued at the right hand points on each graph.

and right side of the glass plate. Whether or not this is significant, I do not know. Possibly the behavior toward the left side was modified because just 4 days earlier the fish had ex-

perienced pin points in the same position facing toward the left.

Observations were not extended beyond about 30 minutes after removing the object, so the duration of the behavioral patterns is not known. After a lapse of 30 minutes, the fish generally exhibited no apparent change in behavior upon approaching the former site of the obstacle; it appeared to have adjusted to the change. Yet, the occasional abrupt close-range avoidance might conceivably occur for some time after 30 minutes.

TABLE III

CHRONOLOGICAL CHANGES IN THE REACTIONS OF AN INDIVIDUAL *Anoptichthys* UPON APPROACHING AN OBJECT HAVING A PIN-STUDDED SURFACE

The object was placed in the aquarium on December 3 at 1349 hours; fish had resided in aquarium 2 days. Total number of approaches is compared against number of approaches that ended in collisions.

Time of observation	Number of		Manner of approaches	
	Approaches	Collisions	Hesitant	Unhesitant
Dec. 3:				
1349–1405	29	29	1	28
1430–1518	30	25	17	13
1630–1640	10	6	8	2
Dec. 6:				
0900–0910	18	4	16	2

LEARNING TIME.—Transferred to an aquarium housing a pin-studded obstacle, the fish exhibited various patterns in the frequency of their approaches toward the obstacle and in the percentage of approaches that terminated with collisions (Fig. 4). *Astyanax* A and C and *Anoptichthys* indicated rather uniformly that they had learned to avoid the pin points within the first 25 minutes. Inasmuch as the observations heretofore indicated that the fish never learn to avoid "undetectable" objects permanently, it was assumed that they had expressed their maximum ability when the collisions in a 5-minute interval fell to a minimum. The evidence strongly indicates, especially for *Astyanax* A and C, that the position of the object was learned in less than 20 minutes. The learning process is suggested not only in the decreasing frequency of collisions, but also in the decreasing frequency of approaches, and was best illustrated by *Anoptichthys*. This point was further illustrated by the reactions of a second *Anoptichthys* (Table III). During the first periods, the hesitant approach commonly ended with a collision, but as the fish accumulated experience, fewer collisions occurred.

DISCUSSION

The results of these studies lead to somewhat different conclusions and interpretations than those arrived at by other workers regarding the ability of *Anoptichthys* to avoid objects and the sensory mechanisms involved in such avoidances. Hubbs and Innes (1936) reported: "They sense the sides of the aquarium rather well, for when excited they only bump the sides occasionally". Breder (1943) stated: "There is, however, no evident distance perception of obstacles as reported for other species of cave fishes. Placed in a strange environment they freely 'stumble' into obstructions. In a short time they seem to learn the location of such objects by trial and error and from then on avoid them. Changing the position of a rock, however, will force the fish to learn all over again." The conclusions in these two papers, opposed as they were, prompted Lüling (1954) to study the matter further. He placed two hungry adult fish in an aquarium containing a vertical plate-glass barrier perpendicular to one side, and allowed the fish 30 minutes to overcome the excitement induced by transferring them. During the next 30 minutes, he recorded the number of times that the fish approached the obstacle and the proportion of approaches that led to contact. A second 30-minute record was made three weeks later. In the first record, the fish approached 111 times and established contact 68 times (60.2%). In the second record, they made 84 approaches and 33 hits (39.2%). From these results, he concluded, "Altere *Anoptichthys jordani*, di sich neu in einem Wasserkörper befinden, stossen, wenn sich in ihrer Schwimmbahn ein Hindernis befindet, in Durchschnitt in gut 60% aller Fälle dagegen (wenn auch niemals stark), verbleiben sie langere Zeit in dem betreffenden Wasserkörper, meiden sie häufig die durch einen Widerstand unterbrochene Schwimmstrecke und stossen weniger häufig (in gut 39% der Fälle) an. Alles in allem scheint es aber doch so, als wenn sich

tatsächlich ein Sinn für Entfernung und Raum ausgebildet hat, so dass wir in übertragenem Sinne mit einer gewissen Berechtigung sagen können das die Tiere allmählich ihre Wasserkörper kennenlernen." (Translated literally: Adult *Anoptichthys jordani*, which find themselves in a strange aquarium, swim into a solid obstacle on the average, in about 60% of their approaches (although never forcefully). After they have resided in the aquarium for a longer time, they frequently avoid the obstacle by swimming around it and swim into it much less frequently (about 39% of the approaches). Everything considered, it appears as though they developed a sense of distance and space, so that we, in the sense of transcribing, can say with a certain right that the animals gradually learn their aquarium.)

The variable behavior of *Anoptichthys* under different conditions and, at times under constant conditions, has perhaps been the basis for the different opinions on the sensory mechanisms involved in their avoidance of obstacles. If the fish repeatedly collide with an unfamiliar object, it is evident that the surface of the object is not subject to distance perception, or, if it is, that the information received by the fish is not integrated in the central nervous system in the usual way. Failure to integrate information received might occur in disturbed fish. But in the present studies the disturbance of being transferred to a different aquarium did not lead to collisions into solid obstacles.

A distinction must, of course, be made between a collision and mere contact. Only a collision can be definitely labeled accidental. Mere contact, from all appearances, is a normal response, the fish having received fore-warning of the presence of the object. Whatever the motivation might be, such contact furnishes the fish with tactile and chemical cues. The frequency with which a fish established contact with a surface might relate to the attractiveness of the surface, a point which was not investigated.

It would seem illogical to suggest that the fish are compelled to learn the position of a solid object, one which they can detect without contact. There is no necessity for such learning as was shown by the ability of the fishes to avoid a solid on encountering it for the first time even in a strange aquarium. It seems likely, nonetheless, that blind fish with a certain ability to remember the spatial relationships of objects, like *Anoptichthys*, would remember the approximate positions of solid-surfaced, innocuous objects after becoming familiar with the total configuration of the aquarium.

One of the original objectives of these studies was to find out if the blind *Anoptichthys* depended on some mechanism of distance perception or direct contact (learning or memory) in avoiding collisions with solid surfaces. Apparently the fishes do not "memorize" the position of a solid object even after long familiarity with it. Their manner of approach and avoidance remains the same from the beginning. That they do not necessarily "memorize" the position of solid objects was also shown in their unhesitant manner of swimming through a site formerly occupied by such an object. If the fish relied upon memory in avoiding solid surfaces, they would periodically swim into the surface with relatively great impact because they demonstrated no ability to remember positions precisely.

This lack of precise memory of spatial relationships signifies that the ability of a blind or blinded fish to avoid collisions (but not necessarily contact) with the walls of an aquarium depends on "distance-perception" of cues. Although I had originally thought that some reports in the literature might be of questionable significance because there was no mention of the fishes' familiarity with the aquarium, it is probable that such conditioning is not a limiting factor. In my own experience, familiarity with the general behavior of a species proved to be an important prerequisite to interpreting their movements. Depending somewhat on the species, it was not difficult to determine whether or not an avoidance was executed in response to memory as opposed to the reception of cues at a distance. However, in order to determine unquestionably whether or not a fish established contact with a surface, I was forced to rely upon cinematographs, even after long experience.

Contrary to the foregoing, if a blind or blinded fish does collide with a solid surface, there is apparently no simple way to analyze its behavior. *Anoptichthys* has an ability to learn the spatial relationships of its surroundings, but, as pointed out, cannot remember positions exactly. No doubt, this ability to remember is expressed in some feature of the fish's overt behavior, but it seems to come into play notice-

ably only with regard to objects that are not subject to distance perception and that produce noxious stimuli upon contact. Because they are able to learn the position of an object in less than 25 minutes after being transferred to a strange aquarium and because they are able to avoid solid surfaces upon encountering them for the first time after being transferred to a strange aquarium, it would seem hazardous to employ the procedure of Lüling (1954), i.e., to allow the fish 30 minutes to overcome the excitement induced by transfer before initiating observations on their ability to learn to avoid solid objects.

The combined roles of memory and distance perception enable *Anoptichthys* to avoid most objects and to lessen their frequency of collisions with others. Being naturally blind and living a cavernicolous life, they might be expected to demonstrate special abilities in this respect, but my observations on other species, and accounts in the literature (Dijkgraaf, 1933 and 1947; Crozier, 1918; Bateson, 1890; Eigenmann, 1909; Lüling, 1954; Hubbes and Innes, 1936) indicate that fishes in general, deprived of visual cues, are able to avoid collisions with solid surfaces.

It is probable that most species, deprived of their visual sense, can detect motionless objects, because through their flight reactions they demonstrate an awareness of slight motions of small objects near them. The stimulus is qualitatively similar whether the obstacle is moving toward the fish or whether the fish is moving toward a motionless object. However, the response that a particular species shows toward a solid surface may be determined not only by the quality but also by the quantity of the stimulus. One point is certainly clear, in studying the responses of moving fish, the object must be as nearly motionless as possible. Bateson (1890), in his studies on blinded bream and pollack, wrote "The sensibility of these fishes to movements in the water must be extremely delicate, for if a straight wire is put in the path of a blind fish it will be avoided if the finger only is kept on the top of the wire, though it does not avoid it if the wire is standing by itself." Similar behavior has been reported on *Amblyopsis* by Eigenmann (1909), and Crozier (1918) in his work on blinded *Epinephelus striatus* points to the importance of preventing any vibrations in the test object. Dijkgraaf (1950) extols the ability of blinded *Gobius paganellus* to detect "das zitterende Ende einer möglichst ruhig gehaltenen, 1 mm. dicken Glasnadel," and has reported similar findings for several other species of fishes (Dijkgraaf, 1933, 1947, 1950).

Disturbances in the water generated by shifting objects to new locations might conceivably confuse the fish and account for some collisions into solid surfaces because such disturbances generally cause the fish to dart around excitedly from place to place as they do when one attempts to catch them in a dip net.

The quality of a stimulus is graphically similar whether the fish swims toward an object or whether an object is moved toward a motionless fish. Perhaps the failure of fishes to avoid swimming into small stationary objects whereas they move away when the same object is advanced toward them is an expression of the Weber-Fechner quantitative law of sense excitation. The general level of stimulation of superficial mechano-receptors is lower for a stationary fish than it is for a fish in motion. Expressed as a percentage change, the stimulus is much smaller when the fish approaches the object than it is when the object approaches the fish though the measured value of the change may be the same. The difference in behavior might then be an expression of the fish's ability to discriminate between relative change.

There is no doubt that the avoidance of a solid surface depends on the fish receiving a mechanical stimulus which is generated as the fish bears down on the surface. So far as is known, as has been pointed out by Dijkgraaf (1947), there are but two possible kinds of stimuli available, both being pressure changes in the water. One possibility is that the movements of the fish generate vibratory changes in the pressure that are reflected back from the surface to the fish. That other possibility is that the fish, moving toward the surface, experiences an increase in the water pressure acting on its advancing surfaces. Dijkgraaf (1947, 1952) asserts that it is the increase in pressure and not the echoes of vibratory changes that the fish perceives.

Summary

1. *Anoptichthys* are attracted to sounds made by an aeration nozzle bubbling in water.

2. *Anoptichthys* and blinded *Astyanax* avoided contact with a flat glass barrier upon approach-

ing it for the first time immediately after they had been transferred to a strange aquarium.

3. *Anoptichthys* and blinded *Astyanax* seldom collide with solid surfaces unless they are unduly excited or disturbed, but they frequently establish contact with the surfaces. *Anoptichthys* commonly forages over the vertical surfaces as though feeding.

4. It is impossible to determine consistently with the unaided eye whether or not the fish establish contact with an object, because they often execute avoidance maneuvers at very close range and while swimming rather rapidly.

5. *Anoptichthys* apparently does not "memorize" the position of solid surfaces, as was indicated by their common behavior toward familiar and strange surfaces and by their unhesitant manner of swimming through a site that had formerly contained a solid surface.

6. *Anoptichthys*, and other blinded species, learned to avoid objects that they apparently could not detect except through direct contact. At first, *Anoptichthys* and blinded *Astyanax* repeatedly swam into surfaces composed of spaced pin points, but in fewer than 25 minutes, at the expense of less than 20 impacts, they learned to avoid the site. Having learned this, they continued to avoid it for at least half an hour after the object had been removed, having passed through the site occasionally during that interval.

7. *Anoptichthys* and blinded *Astyanax* are not able to remember spatial relationships precisely. They commonly initiated avoidances of the pin points at distances of 6 to 8 inches and also frequently swam into the pin points while approaching slowly and hesitantly. This type of approach suggested that the fish were able to remember their approximate spatial position. After removing the pin-studded object, the fish persisted in executing avoidances of the site at distances as great as 6 to 8 inches and commonly executed the avoidance after they had passed part way across the site formerly occupied by the points. These observations indicate that the fish would commonly collide with solid surfaces if they depended on their memory of spatial relationships rather than on their perception of mechanical cues received at a distance, and showed also, that the fish never succeed in avoiding pressure-transparent objects persistently.

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Franklin and Marshall College, Lancaster, Pennsylvania.

A Note on Preliminary Stages in the Fossilization of Fishes

C. M. Breder, Jr.

The requirements of the earliest stages in processes of fossilization have been little studied, especially of those which take place under water. Ordinarily, if a fish dies and is not promptly devoured, it merely rots and completely disappears, usually within a matter of

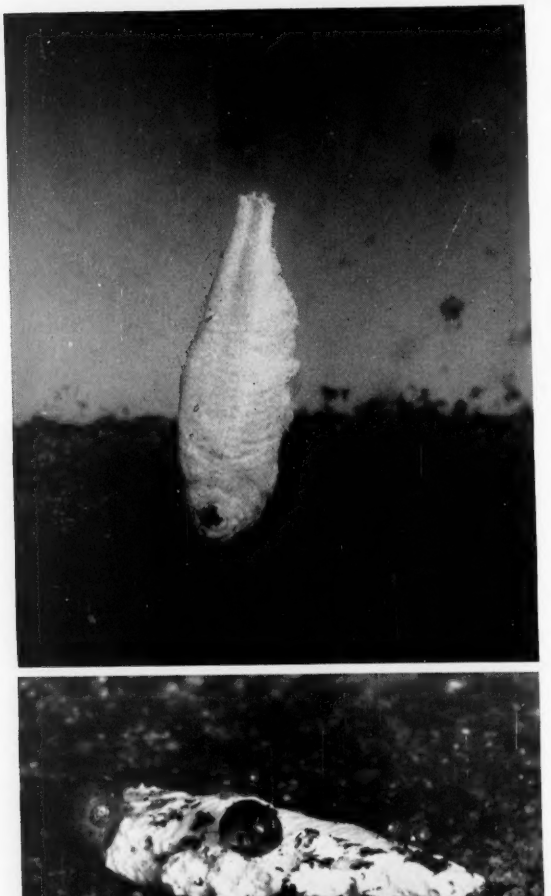

Plate 1. Photographs of the second fish which failed to decompose. Upper: the condition 22 days after the death of the fish. Note the light color of the fish as compared to the surroundings. It is standing on end because of some gas contained in the body cavity. Lower: the condition 40 days after the death of the fish. The gas has disappeared and the fish is now reclining on one side. The snails are passing over it as they would any rock or similar solid, not feeding on it.

weeks, depending largely on its size and the temperature of the environment. Omitting polar preservation by refrigeration, which at best could only delay the onset of the initial steps of decay or of fossilization, it is clear from the abundance of fish fossils that all dead fishes do not suffer destruction by either larger or smaller organisms. Obviously, under certain fairly widespread conditions in temperate or warm climates there have been certain concatenations of events which must have made possible the first step leading to fossilization.

Certain unexpected occurrences which took place in a laboratory aquarium of standing warm fresh water, would seem to throw light on the nature of a possible first step in the fossilization of fresh-water fishes. Owing to the pressure on laboratory personnel caused by extensive moving operations various aquaria were somewhat ignored. The fishes, *Astyanax mexicanus* (Filippi), the remainder of some completed experimental work, were fed but otherwise neglected. When finally they were examined, it was noted that there was a dead fish in one of the aquaria which had not decomposed and was rather rigid. Its single tank-mate was still living. Both had been old fish, about two inches long, senile and near the end of their normal span of life. The living one was radiographed and returned to its tank. This was done in order to determine whether there was some pre-mortum moribund or other change which might conceivably lead to the condition of the dead fish. The fish proved to be completely normal so far as the radiograph indicated. This fish died later, evidently of old age, on October 12, 1952.

The pH of the water had been taken two days before and found to be 6.6 which was about normal for these aquaria. The waters in three other near-by and similar aquaria measured 6.6, 6.6 and 7.0. The aquaria contained a considerable number of *Planorbis* and *Physa* which at all times were active and appeared vigorous. The second dead fish did not rot and turn black as such fishes usually do, nor was it consumed by the snails. Either fate is of course normal in such aquaria. The fish became a chalky white and was photographed in place on November 3, a matter of 22 days after its demise. The temperature of the water averaged about 24° C and the conditions were such that normally lead to rapid putrefaction and dissolution of any such small fish. At this time there was evidently some gas contained in the body cavity as it stood on end as shown in Plate 1, upper figure. It was again photographed on November 21, 40 days after death, and was seen to be unchanged except that the gas had evidently dissolved and the fish lay on the bottom. Snails crawled over it at will but apparently made no attempt to eat it, Plate 1, lower figure. The aquarium was allowed to remain undisturbed. By June, 1953, a matter of about eight months, the fish had gradually disintegrated evidently by incidental mechanical movements of the rather large snail population which kept increasing in number over this period. Fragments of the fish were scattered over the floor of the aquarium at random and the experiment was terminated.

Five slightly smaller dead characins, killed for the purpose, on November 21, 1952, were placed in a similar aquarium for comparison. These took the normal course, rotting to an evil-smelling paste in a short time. This aquarium was also left undisturbed and by March, 1953, had returned to a clear "healthy" appearance with no evidence of the dead fish remaining. They had been reduced partly by being eaten by snails but mostly by bacterial decomposition and eventually had gone into the support of a luxuriant growth of aquatic plants. The local water supply is low in calcium and any calcium bearing materials pit rapidly and eventually dissolve away entirely, so that the skeletal parts would not be expected to remain intact for long.

Chemical analysis of the materials found in the original "fossil" and in the water of that aquarium and its adjacent companion were obtained through the kindness of Dr. E. C. Olson at the University of Chicago. These analyses, spectroscopic, follow:

"Fossil" fish. Ca. (Much of this is in some complex organic salt.) Inorganic: all small amounts; Ca, Mg, Si, Fe, Al, Ba, Sn. Traces: B, Mn, Cu.

Water from "fossil" aquarium. Ca, Na, Mg, Fe. Traces: Si, Al, B, Mn, Cu, Sr, Ti.

Water from another aquarium. Ca. Traces: Na, Si, Al, Mn, Cu, Sn, Ti, Sr, Ba.

These analyses are more or less typical of aquarium water in the vicinity of New York

City. In terms of percentage, calcium was found to be low in the "fossil" itself but since most of it was organic, as checked by X-ray analysis, it was evidently driven off in burning during analytic procedures. If there were a true concentrating mechanism of calcium in the activity within the dead fish, this should be able to account for its low concentration in the water of the aquarium.

It so happens that the fish in the "fossilizing" aquarium had been fed tubificid worms and it was noted that the sand in this particular tank had darkened but that there were many of the worms there in an active colony. Evidently more than sufficient worms had been placed in the aquarium and some had died in the sand, leading to the production of a black muck which accumulated in parts of the tank. These worms are gathered near the outlets of municipal sewers by collectors and sold to aquarium hobbyists for live fish food. Along with them comes a certain amount of black structureless but evil-smelling muck which consists mostly of reduced faeces.

Since it has long been known that such places are a source of bacteriophage and that its presence has also been demonstrated in old aquarium water (Breder, 1931) it was first thought that this failure to decompose might be caused by the presence of some lytic activity interfering with the normal process of putrefaction. As a preliminary step toward the determination of what bacteria might be present some agar smears from this aquarium and others were made by Mrs. E. Atz and Miss Louise Stoll. These showed that there was a distinct difference in the number and kinds of colonies from the "fossilizing" aquarium and the others. Dr. Carroll W. Grant of Brooklyn College was called in for advice on the nature of the bacterial flora which might be involved. He examined the agar smears and made some preliminary cultures from them. From the aquarium yielding the peculiar results noted he identified *Pseudomonas non-liquifaciens* (more generally considered a synonym of *Pseudomonas eisenbergii* Migula) which was not found in other aquaria used for comparison. Antibiotic activity is a general character of this genus. In these preliminary examinations of organisms from the aquarium in question as well as others from other sources which were of known antibiotic activity, he was able to note what appeared to be some retardation of the decomposition of dead fish in a beaker. Unfortunately it was impossible for him to continue work along this line.

Lest it be thought that this situation is an absolutely unique one, it may be mentioned that once before a somewhat similar occurrence was noted, but at a time when it was impossible to investigate the cause. This case appeared in the course of experiments wherein female *Lebistes reticulatus* (Peters) were confined alone in small aquaria prepared of very old "conditioned" water from a larger aquarium. One female, which died from unknown causes, remained intact for a period of three months or more with no evidence of decomposition. Finally the fish appeared to wither as though under a process of dehydration. There were no snails or other macroscopic organisms in this tank which may account for the fish remaining intact.

It does not take any very great leap of imagination to visualize some swamp hole as a biochemical equivalent of the aquarium conditions of the kind discussed. Since in these aquaria fishes remained virtually intact for a matter of months, there would seem to be adequate time, in a similar situation in nature, for the dead fishes to sink into the pond bottom mud or to be silted in and effectively sealed to await the slower geologic processes of petrification.

What Clarke (1924) wrote in reference to coal formation has distinct bearing on the above considerations. "How far micro-organisms are active in the formation of coal is doubtful. They abound in the stagnant waters of swamps, and certainly have much to do with the earlier stages of vegetable decay. They start the process, but at the same time they generate antiseptic compounds which limit their activity. Peat, not far below the surface, is distinctly antiseptic and inimical to microbian life." Thus, between the time from death until petrification has an opportunity to begin, there is evidently a period where the possibility of eventual fossilization is determined largely by the relationship of bacterial activity to its inhibition. That such considerations are within the reach of the experimental procedures of bacteriologists, virologists and biochemists would seem to be evident.

Dence (1956) reported finding numerous fish bodies, on the shores of Lake Onondaga, which seem to resemble those herein described. This occurrence may or may not have bearing on present considerations. It is recognized that the conditions described by him may represent an entirely different phenomenon, only superficially resembling the described aquarium conditions. However, if an unusual presence of antibiotic organisms could be demonstrated to be present in this lake or associated with the source of these evidently non-decomposing fish bodies, such evidence would strongly suggest that the two cases had some relationship. In such an event it would seem that the observations by Dence might be a naturally occurring representation of some stage in the process described herewith as occurring in aquaria.

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A New Genus and Species of Elopid Fish (*Laminospondylus transversus*) from the Upper Cretaceous of Texas

Victor G. Springer

Between March, 1939, and September, 1941, the state-wide Paleontologic-Mineralogic Survey of the Works Project Administration, sponsored by the Bureau of Economic Geology, University of Texas, recovered a considerable number of vertebrate fossils from localities throughout Texas. Among these fossils was a large group of Cretaceous fishes, primarily from Fannin and Grayson Counties in the northeastern part of the state. Since their recovery and subsequent partial preparation these specimens have received little attention other than in the mimeographed final report of the Survey (Evans, 1941). The treatment therein was necessarily incomplete and cursory. The present study is offered to direct attention to the material and to make known one of its more interesting and unique constituents.

Sincere appreciation is due to Dr John A. Wilson, Department of Geology, University of Texas, for suggesting the problem and for his invaluable criticisms during the course of the work and the writing of the manuscript. Dr. E. I. White, British Museum, gave information concerning *Leptolepis macrophthalmus*. Dr. Clark Hubbs, Department of Zoology, University of Texas, read the manuscript and offered criticisms. Mrs. Jane Hubby executed the drawing. Collections and field preparations were under the immediate supervision of Mr. Lloyd J. Ryman.

Location and Geology

The material was from two quarries, one each in Fannin and Grayson counties. The following descriptions of these sites and their geology is mostly taken from Evans (1941).

Fannin County, Savoy Pit. Location No. 31051; Site No. 1. "This quarry may be reach by going south on surfaced road four miles from Savoy and turning east on dirt road for 0.75 mile. The quarry is on the west slope of the hill just beyond the first creek south of road. At this site fossils were obtained from the Ector Chalk, a basal member of the Austin Formation. in northeast Texas. Blue Eagle Ford shale forms the floor of the Savoy Pit. For ten feet above the shale, the walls consist of blue-gray argillaceous limestone cut by numerous vertical joints. Above this are two to three feet of thin-bedded limestone overlain by up to three feet of black clayey soil. Nodules of pyrite are widely scattered throughout the matrix."

Grayson County, Wallace Quarry. Site No.

3. "H. G. Wallace farm, 6.5 miles northwest of Sherman, in the base of the Austin chalk, a horizon [the same] as the Savoy pit in Fannin County."

In addition to the above descriptions there are pencil maps accompanying the field catalogues in the files of the Vertebrate Paleontology Laboratory, University of Texas.

The Ector Tongue of the Austin Chalk has not received much attention since its description by Stephenson (1918) wherein he stated that the tongue had been traced from western Fannin County northeastward to a point about one and one-half miles southeast of Ravenna, also in Fannin County.

The matrix surrounding the specimens from Grayson County is not distinguishable from that of the specimens from adjacent Fannin County and is possibly contemporaneous and continuous with it. The extent of the Ector Tongue of the Austin Chalk is yet to be fully described.

The entire matrix is characterized by the presence of extraneous scales and bits of bone.

The associated fauna has been only cursorily examined. The following forms were listed as occurring in the formation by Evans (1941), and also on the field data sheets:

Savoy Pit. *Inoceramus*, *Enoploclylia*, selachii, *Ptychodus mortoni*, *Xiphactinus* (a fifteen foot specimen was collected), mosasaur, and plesiosaur.

Wallace Quarry. *Inoceramus*, lobster, selachii, *Ptychodus*, and mosasaur.

In addition to these forms and several unidentified teleosts were many specimens of the clupeid fish *Scyllaemus* from both quarries.

Material

The material consists of fourteen specimens. Nine of these contain portions of skulls, of which eight are preserved from the ventral side and one latero-ventrally. The remaining six specimens consist primarily of portions of the vertebral column. None of the specimens are complete, and in every case the skulls have been crushed to such an extent that no restoration can be made; only a few of the skull bones can be identified.

The bones vary in color from light to dark brown; the matrix is blue gray.

Four of the specimens were cleaned by me using a fine needle under a binocular microscope; the other ten specimens were primarily cleaned by preparators unknown to me, and needed only minor cleaning.

Order Isospondyli

Family Elopidae (?)

Genus *Laminospondylus*, *gen. nov.*

Elongate fishes, scaled only on the anterior one-third of the body. Vertebrae 44 to 48, with all of the centra, except those of about the last six caudal vertebrae, bearing elongate, broad laminar transverse processes which are directed anteriorly and articulate with the posterior portion of the centrum of the next anterior vertebra. Type species *Laminospondylus transversus*.

Laminospondylus transversus, *sp. nov.*

Plate I

Holotype.—Bureau of Economic Geology, University of Texas. 40092: a ventrally preserved fish with skull and vertebral column, paired and caudal fins; preserved in counterpart.

Paratypes.—B.E.G. 40092-9: a ventrally preserved fish with skull, paired fins, and some vertebrae. B.E.G. 40092-15: several posterior vertebrae and a portion of the caudal fin. B.E.G. 40092-16: a ventrally preserved fish lacking the snout; caudal fin preserved laterally; preserved in counterpart. B.E.G. 31051-29: a ventrally preserved fish with skull and anterior vertebrae. B.E.G. 31051-33: a group of vertebrae just posterior to the skull. B.E.G. 31051-35: a ventrally preserved posterior portion of a skull and anterior vertebrae. B.E.G. 31051-36: a posterior portion of vertebral column and caudal fin. B.E.G. 31051-40: a ventrally preserved posterior portion of a skull and anterior vertebrae. B.E.G. 31051-41: a badly damaged ventrally preserved fish; preserved in counterpart. B.E.G. 31051-42: a ventrally preserved fish in several pieces; preserved in counterpart. B.E.G. 31051-43: a ventro-laterally preserved fish lacking snout and fins. B.E.G. 31051-44: counterpart of a large section of abdominal vertebrae. B.E.G. 31051-45: a ventrally preserved skull and portion of vertebral column.

Those specimens with the prefix number 40092 were retrieved from the Savoy Pit in Fan-

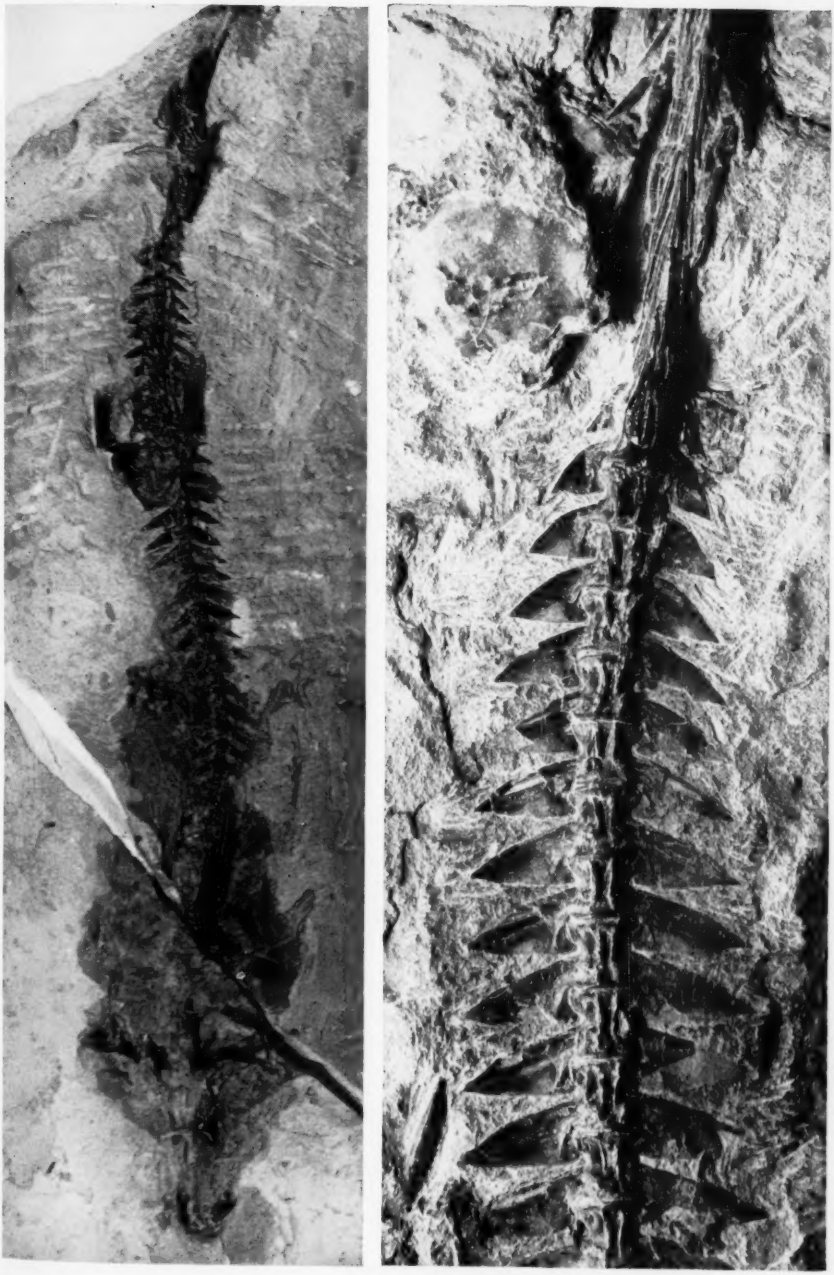

Plate I, upper. B.E.G. 40092-2. Holotype of *Laminospondylus transversus*, 270 mm. total length. Ventral view. lower. B.E.G. 31051-36. Section of abdominal and caudal vertebrae of *Laminospondylus transversus*. Dorsal view.

nin County. Those specimens with the prefix number 31051, except numbers 44 and 45, were retrieved from the Wallace quarry in Grayson County. Numbers 31051-44 and 45 are missing locality data, but are presumed to have been taken from one or the other of the two sites.

Bones of the Skull

None of the dermal bones of the dorsal side of the skull are visible in any of the specimens due to the nature of preservation.

Of the opercular series only the preopercles could be discerned with certainty, and these are complete in specimen 40092-9 only. They are thin bones and have been badly crushed, but their outline persists. They form a broad crescent posteriorly which tapers ventrally and anteriorly into a long arm. The arc formed by the crescentic portion and the arm is approximately ninety degrees, and the ventral arm measured from this arc is slightly longer than the depth of the preopercle. Little of the ornamentation of this bone could be discerned. Inasmuch as the preopercles are well removed from the jaws in this specimen, it is considered that they were displaced during preservation.

The hyomandibular in normal position is well shown in specimen 31051-43, where it is superimposed upon a gill whose filaments are well preserved. This bone has roughly the shape of an elongate trapezoid and approximates closely the general shape and structure of the hyomandibular of the elopid genus *Megalops*. The superior border of the hyomandibular appears to be level and the two heads for articulation with the neurocranium are not distinguishable. There is a projection from the dorsal portion of the anterior border, but this is obscured by superimposed fragments of bone, presumably of the preopercle. The posterior portion of the hyomandibular gives rise dorsally to a gentle swelling, the articular head for the opercle; this is also raised laterally. There is a rounded median ridge running down the lateral surface which merges into the inferior extension for articulation with the symplectic and urohyal; these latter two bones were not seen.

None of the other bones of the quadrate or pterygoid series could be discerned.

The epihyal and portions of the ceratohyal are visible in several specimens, but are described here mainly from 31051-43. The epihyal is roughly triangular with its posterior apex enlarged into a rounded joint for articulation with the urohyal. It has on its external surface a narrow groove which is continuous on the ceratohyal. Only the posterior portions of the ceratohyal are present in any of the specimens. This bone is longer than the epihyal and also triangular in shape. Portions of approximately sixteen branchiostegal rays were seen in one specimen. It is estimated that more were present.

The maxillary, shown best in specimen 40092-9, is an elongate curved bone extending posteriorly about one-half the length of the skull. Its shape would indicate that supplementals were present, but their sutures are not visible. No teeth are to be seen on this bone or any of the other jaw bones. If present, they were probably very small.

The dentaries in specimen 40092-9, viewed ventrally, are short, heavy bones with broad, rounded rami projecting posteriorly for about the same distance as the maxillary. From the little that could be seen in a deep lateral excavation, it appears that the dentary possessed a large coronoid process of the type found in *Megalops*.

The articular in the same specimen is blade-shaped with raised rounded margins along the dorsal and ventral borders, thus leaving a flat, posteriorly directed triangular area between them for articulation with the dentary. The borders coalesce posteriorly into a hook-like articular process for receipt of the quadrate. This hook was unfortunately lost in a later attempt at cleaning.

None of the bones of the ventral side of the skull (including the presence or absence of a gular) could be ascertained; nor any of the pectoral girdle or branchial apparatus, except the gill lamella mentioned above. This latter element was a little wider than the broadest portion of the hyomandibular, and about one and one-half times as deep. Individual filaments are plainly visible.

The Fins

In none of the specimens are dorsal or anal fins preserved.

The pectoral fins are located ventrally about one-third of the way back along the total length of the specimen. In specimen 40092-9 they consist of sixteen rays on the left side and seventeen

on the right. The longest pectoral ray is a little more than twice the length of the longest pelvic ray, but does not reach to the origin of the pelvic fin.

The pelvic fin is attached to a long, broad, triangular pelvis which extends anteriorly from the origin of the fin for a distance of about six abdominal vertebrae. The origin of the fin rays is situated about two-thirds the distance of the total length from the head. The fin may consist of seven to nine rays as indicated by counts of seven fins, with eight rays occurring four times.

The caudal fin, which occurs laterally in only one specimen, is forked. It takes its origin from elongated haemal and, to a lesser extent, neural arches. The exact nature of the proximal elements of the fin are obscured, but it appears that there are some broad, blade-like hypurals present for support of the rays, which number approximately nine on each limb of the fin.

The Vertebral Column

On two specimens the vertebrae numbered forty-four and forty-five; on a third they were estimated at forty-eight.

The vertebrae are strikingly characterised by the presence of long, broad, laminar transverse processes (Pl. I, lower and Fig. 1). These processes arise mid-laterally from the anterior half of each centrum. They are directed anteriorly and overlap and articulate with the posterior half of the centrum of the next anterior vertebra. The processes reach their maximum development midway on the vertebral column, at which point the lateral extension of a single process is equal to about twice the diameter of the centrum. The processes gradually decrease in size anteriorly until they appear as overlapping hooks at the base of the skull. Posteriorly they decrease in size gradually until about the sixth from the last vertebra, and from this point on are apparently absent. In about this region the vertebrae develop strong neural and haemal arches, and those from the last two or three vertebrae take part in the formation of the caudal fin.

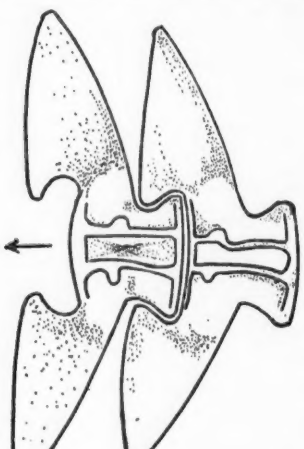

Fig. 1. Semi-diagrammatic drawing of two abdominal vertebrae of *Laminospondylus transversus*. Dorsal view, the arrow directed anteriorly.

The centra are hour-glass shaped with a pair of longitudinal laminae both dorsally and ventrally cutting off gullies. The bases of the transverse processes act as lateral laminae for dividing the centra into dorsal and ventral halves so that dorsal and ventral fossae are formed on each side of the centrum between the dorsal and ventral gullies, making a total of six compartments on each vertebra.

The centra are well ossified, though excavated. If a notochordal canal persists, it is extremely small and not identifiable as such.

Numerous intermuscular bones are scattered around the vertebrae, especially anteriorly. A few ribs are seen on some of the specimens, but the nature of their articulation has not been preserved. It is presumed that they articulated with the transverse processes.

Squamation

The body is scaled on its anterior one-third only. These scales are closely imbricate and do not appear to contain a ganoine layer. That the present species had scales on the posterior parts of its body is doubtful. The nature of the matrix is such as to be favorable for the preservation of scales, for as stated above in at least one case the gill filaments are discernible, and one would expect that in at least one of the specimens some scales, if present, would be found in the posterior regions.

Measurements

(Measurements are given in Table I.)

Discussion

The present assignment of *Laminospondylus* to the elopid and not the clupeid line of fishes

TABLE I

MEASUREMENTS IN MILLIMETERS OF *Laminospondylus transversus*

Specimen No.	Total length (approx.)	Head length (approx.)	Length longest pectoral ray	Length longest pelvic ray	Length longest caudal ray
40092-2	270	63		16	30(approx.)
40092-9	220	40	R. 28 L. 27.5	12.5 12	
40092-16	300	70			47

must be considered tentative until such time as the nature of the membrane bones and post-temporal area of the skull are known. As a guide in identifying skull structures, a skull of *Megalops atlanticus* was employed. In proportions and general topography the fossils agreed well with the recent material. A comparison of *Laminospondylus* with *Elops saurus* shows many similarities, but differences of importance are seen in the structure of the dentary and hyomandibular. In *Elops* the dentary has what may be considered at best a poorly developed coronoid process. The hyomandibular of *Elops* is hatchet-shaped with a broad head and an abruptly slender ventral arm. The exclusion of the clupeids from consideration in this paper is based primarily upon vertebral characters which are discussed below.

Within the elopid line of fishes, the Albulidae and their allies may be excluded from consideration on the basis of their highly modified jaws. In contrast to other elopids, the maxillary of the albulids is much shorter than the combined length of the dentary and articular; and its length is contained three to four times in the length of the skull, as compared to two times in the Elopidae, and also the Leptolepidae. The distinction between these last two families is much less sharp. Dunkle (1940) based a separation of the Elopidae and the Leptolepidae on a comparison of the skulls of *Notelops bramma* with *Leptolepis bronni*; the important character being the absence of basipterygoid processes on the parasphenoid of *Notelops*. The living elopids also lack these processes. It was not possible to determine the nature of the parasphenoid in *Laminospondylus*. Dunkle also considered the gape of the Leptolepidae to be small and, as such, a specialization when compared to *Notelops* and *Elops*. I feel that this is possibly a misconception. The bones of the jaws are similar in *Leptolepis bronni*, as reconstructed by Rayner (1937), and *Megalops atlanticus*. If the jaws of a fresh specimen of *Megalops* are manually spread without forcing, it will be found that the jaws are capable of considerable expansion, proportionately as great as that of *Elops*. Woodward (1895) figures a fossil of *Leptolepis macrophthalmus* with the jaws expanded and exhibiting a large gape. The small gape of *Leptolepis bronni* is probably an artifact of reconstruction. Dunkle was, however, impressed by the degree of specialization of the leptolepids in the direction of the Elopidae, and felt that prior considerations of the leptolepids as generalized primitive teleosts were uncritical. It is conceivable that when the osteology of more of the fossil forms is known the Leptolepidae and the Elopidae will be combined.

Examination of the vertebrae of several recent clupeids evidenced no structures comparable to those of the transverse processes of *Laminospondylus*; whereas, the recent elopids, *Elops* and *Megalops*, and possibly the fossil *Leptolepis macrophthalmus*, have a structure which might have been derived from, or in the latter case given rise to, the transverse processes of *Laminospondylus*.

A rough drawing of three vertebrae of *Leptolepis macrophthalmus*, sent to me by Dr. E. I. White, shows the presence of laterally expanded, triangular transverse processes which articulate with ribs. The processes are small and the length of the lateral expansion of a process is contained two and one-half times in the diameter of a centrum. The processes do not overlap the vertebra to the anterior. The presence of transverse processes in *Leptolepis* has been noted only in *L. macrophthalmus* by Woodward (1895).

As no description of the vertebrae of *Elops* and *Megalops* could be found which mentioned these processes, they are described briefly here.

The vertebrae of *Elops saurus* are cylindrical with their mid-portions slightly constricted, but not hour-glass shaped. They contain numerous fiber-like longitudinal laminae which connect the anterior and posterior portions of each centrum. The transverse processes are first noticeable on about the seventh from the last vertebra. They begin as minute mid-lateral swellings and gradually take the form of right triangles with the long side directed towards the ante-

rior. The largest of these extends outward for a distance equal to not more than half the diameter of the centrum. None overlap the vertebra to the anterior. In the abdominal region the processes gradually become lower on the centra until they unite with the ribs; at the same time they become posteriorly directed. At a distance of about nine vertebrae from the base of the skull a second transverse process arises from the area just above the first and very minutely increases in size to the axis. It is absent on the atlas, and none of these second processes enter into the articulation with the ribs or, as far as can be told, with the intermusculars.

The vertebrae of *Megalops atlanticus* are constricted similarly to those of *Elops*. The fiber-like laminae have increased in number and fused to form a plate surrounding the centrum; some of the individual laminae can still be discerned. The transverse processes begin as small tuberesences on the sixth from the last vertebra and are mid-lateral in position. They gradually increase in size and shape in a manner similar to *Elops*. They also become ventro-lateral in position. Inter-muscular bones are attached to the processes and in the abdominal region ribs articulate with them also. Anteriorly the processes split, one portion remaining ventro-lateral and articulating with ribs, and the other becoming mid-lateral and articulating with the intermuscular bones.

Specialized transverse processes have arisen separately in other lines of fishes. In living forms *Fistularia*, of the Syngnathiformes (Berg, 1947), has developed paddle-shaped transverse processes. In fossil forms, all the members of the Dercetidae, whose ordinal relationships are still in question, are characterised by bilobed, broadly expanded transverse processes. It is not unreasonable to expect that within certain limitations, the nature of the transverse processes in some groups of fishes may be of considerable phylogenetic significance.

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Department of Zoology, University of Texas, Austin, Texas.

Herpetological Notes

OBJECTIONS TO WHOLESALE REVISION OF TYPE LOCALITIES.—Early workers often omitted a statement of type locality, citing only broad geographic areas or scattered localities. Smith and Taylor (1950, Univ. Kansas Sci. Bull., 33: 313–380) and Schmidt (1953, A Check List of North American Amphibians and Reptiles, 6th ed.), compiling regional checklists, felt constrained to supply missing type localities by subsequent revision. Dunn and Stuart (1951, Copeia, 1: 55–61) expressed the opinion that *fiat* revision of type localities need not be binding on later authors, and objected, mostly on geographic grounds, to many of Smith and Taylor's revisions. I take exception to a number of Schmidt's revised type localities, particularly for species of the southeastern United States. My purpose here is to show by a few examples how problems may be created when type localities are coined without adequate attention to zoölogical considerations and to the literature. The terminology of type locality revision follows Smith (1953, Syst. Zool., 2: 37-41).

1. *Salamandra variolata* Gilliams (1818, Jour. Acad. Nat. Sci. Phila., 1: 460; "Southern states.")—This name is considered a synonym of *Plethodon glutinosus*. Schmidt (p. 34) restricted the type locality to the vicinity of Charleston, South Carolina. Mittleman (1951, Herp., 7: 105–112) considered specimens from the Charleston area to be intermediate between *P. g. glutinosus* and his *P. g. chlorobryonis*. Actually, the Charleston population is *chlorobryonis*. If the type of *variolata* really came from Charleston, Gilliams' name should take prece-

dence over Mittleman's. Schmidt recognized *chlorobryonis* Mittleman and yet considered Charleston the type locality of *variolata*, an impossible situation. The disposition of the name *variolata* should be left up to someone actively studying raciation in *P. glutinosus*. *Salamandra cylindracea* Harlan ("South Carolina," restricted by Schmidt to Charleston) is a similar case.

2. *Spelerpes ruber sticticeps* Baird (in Cope, 1869, Proc. Acad. Nat. Sci. Phila., 21: 108; "Georgia.")—Schmidt (p. 48) listed this name as a synonym of *Pseudotriton m. montanus*, and restricted the type locality to Rabun County, Georgia (in the Appalachian Mountains). I have discussed the status of the name *sticticeps* elsewhere (Neill, 1948, Copeia, 2: 134–136), and consider it to be based on a Coastal Plain or lower Piedmont representative of *P. ruber*. It seemed probable that the cotypes of *sticticeps* came from Augusta, Richmond County, Georgia, where their collector is known to have operated and where a color pattern like that of the cotypes is of frequent occurrence. Restriction of the type locality to Augusta also had the merit of convenience. At any rate, the specimens of *sticticeps* were uniform reddish-brown above, finely sprinkled with black below, and with conspicuously white-flecked snouts (Cope, 1889, The Batrachia of North America: 178); salamanders answering this description do not occur north of the lower Piedmont in Georgia, and could not have come from Rabun County.

3. *Hyla andersonii* Baird (1854; Proc. Acad. Nat. Sci. Phila., 7: 60; "Anderson, South Carolina.")—The original type locality is doubtless in error; but Schmidt's (p. 69) locality (Aiken County, South Carolina) is also outside the range of the species, in my opinion. Aiken County has been heavily collected by many people and over many years, but this frog has not been found there.

4. *Coluber erythrogrammus* Latreille (1802, Hist. Nat. Rept., 4: 141; "L'Amerique septentrionale.")—This name is now used for the rainbow snake, *Abastor erythrogrammus*. Schmidt (p. 185) restricted the type locality to Alachua County, Florida. I have been investigating the taxonomy and natural history of this species, as announced in Copeia 2, 1951, p. 184. Publication has been delayed by a scarcity of material from peninsular Florida, which may harbor a distinct race. If so, Alachua County specimens are apt to be intergrades. (I have examined most *Abastor* in North American collections, but have yet to see one from Alachua County.) A type locality farther north seems preferable. In any event, Harper (1940, Amer. Midland Nat., 23: 714) previously fixed the type locality as "the lower Cooper River, in the vicinity of Charleston, South Carolina," and Harper's arguments are well founded.

5. *Coluber Dumfrisiensis* Sowerby (1804, Brit. Misc.: 5; "Dumfrieshire, Scotland.")—Schmidt (1954, Copeia, 4: 305) considered this name a synonym of *Cemophora coccinea*, and corrected the type locality to Charleston, South Carolina. Pope (1946, Snakes of the Northeastern United States: 34) and Mittleman (1952, Herp., 8: 22–25) noted the existence of a distinct Florida race of *C. coccinea*. Schmidt's correction, if binding, may force us to apply the inappropriate name of *dumfrisiensis* to an American snake, since the name *coccinea* is based on the Florida population. Of course, if Mittleman (*op. cit.*) is followed in transferring the name *doliata* Linnaeus from *Lampropeltis* to *Cemophora*, then *dumfrisiensis* will remain in synonymy, for Charleston is (by restriction) the type locality of *doliata* also. However, there is some reason for retaining *doliata* in *Lampropeltis* (Neill, 1954, Pubs. Research Div., Ross Allen's Reptile Inst., 1: 90). When the name *doliata* has been disposed of to the satisfaction of the majority, and when raciation in *Cemophora* has been studied, it will be time enough to correct the type locality of *dumfrisiensis*, in such a way as to bury this inept name in synonymy.

6. Schmidt (pp. 24, 68, 86, 99, 106, 107, 111) revised numerous type localities overlooking previous and different revisions. Thus, the type localities of *Acris crepitans* Baird, *Eretmochelys squamata* Agassiz, *Testudo imbricata* Linnaeus, *T. serpentina* Linnaeus, *T. caretta* Linnaeus, and *T. coriacea* Linnaeus had all been revised by Smith and Taylor (*op. cit.*); that of *T. picta* Schneider had been corrected by Mittleman (1945, Copeia, 3: 171); and that of *Salamandra dorsalis* Harlan had been restricted by Bishop (1941, Occ. Pap. Mus. Zool. Univ. Mich., 451: 2–3).

Other undesirable revisions could be cited, but the above are adequate for my purpose.

No one doubts that the compilers of checklists, in revising type localities, have intended well. Nevertheless, such revisions should be made only when they become necessary, and then by the one directly concerned with the taxonomy of the species involved; for such an individual is not likely to overlook previous revisions, unpublished zoölogical considerations, and pertinent literature.—WILFRED T. NEILL, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida.*

THE EGG-LAYING HABITS OF THE SALAMANDER, *AMBYSTOMA JEFFERSONIANUM*.—W. T. Stille (1954, *Copeia* (4): 300) reported that in the Chicago area *Ambystoma jeffersonianum* lays eggs singly and in groups contrary to observations made in the east as reported by Bishop (1943, Handbook of Salamanders). This reference is an unfortunate one since in Bishop's

"Salamanders of New York", 1941, there is a more exhaustive treatment of each species and he states on page 94, "The eggs are deposited in small masses which contain on the average about 16, but the number varies from 7 to 60 and often single eggs are dropped, or small clusters of three or four." In support of this quotation the following three observations are recorded on egg deposition by Jefferson's salamander in eastern Canada.

The first discovery of singly laid eggs was on April 30, 1953, near Harvey, York County, New Brunswick. The habitat was a ten foot square, shallow, silt-bottomed spring in a pasture. An old piece of tree trunk lay in the water and lining the cavities and grooves of its undersurface were about 100 eggs attached singly, in rows and in clusters of up to nine eggs. The eggs were newly laid and each one including all envelopes was about 7 mm. in diameter. No salamanders were seen at this spring, but about four miles further west in an old gravel pit adult *A. maculatum* and *A. jeffersonianum* were collected. Attached to the branches of a submerged brush pile were typical egg masses of both species with the small cylindrical *A. jeffersonianum* masses and the large globular *A. maculatum* masses presenting a sharp contrast.

The second observation was made on May 13, 1953, near Les Mechins in northern Gaspe, Quebec. Again the habitat was a pasture spring, but this one had a rock strewn bottom and three feet of water in its deepest portions. The water in the pond was higher than normal and had submerged grass clumps, some *Myosotis laxa* weed and a few boards. Over the stems of the weeds, on the grass and hidden on the undersides of rocks and boards were scattered hundreds of eggs most of them attached singly but some in clumps of up to ten eggs. A few of the eggs were fresh, many were spoiled and some were 12–14 mm. in diameter and ready to hatch. In addition there were many masses of *Rana sylvatica* eggs along the margin of the pond. Under the largest piece of wood three large female Jefferson's salamanders (5.5, 5.5 and 6 inches long) were discovered. Dissection showed that these specimens had not yet laid. The fact that several females had already laid and had deposited their eggs singly suggests that this is the general rule for this population.

The author's nearest collecting site to Les Mechins is across the St. Lawrence River at Seven Islands where recently laid *A. jeffersonianum* eggs were found on June 5, 1952. The habitat was an ancient bog that had nearly filled and become firm and meadow-like with the exception of several small, shallow, boggy pools. In these pools were six typical egg masses all with less than 30 eggs and the one mass collected had a compliment of 21 eggs.

On May 5, 1955, in the pond of an abandoned rock quarry on Ile Perrot, (at the junction of the Ottawa and St. Lawrence Rivers) many spoiled and hatched Jefferson's salamander eggs were observed. They were attached to the branches of a submerged pile of brush and consisted of small egg masses, groups of 2 to 6 eggs and single eggs. One twig had a row of approximately 15 well spaced single eggs.

It is apparent that the phenomenon of *A. jeffersonianum* laying its eggs singly or in small clusters is a widespread one and that in the eastern half of its range all variations of egg deposition can occur in the same area. This condition may even hold true in the Chicago area for Stille says that some of the egg masses in the ponds he investigated were assumed to be *A. jeffersonianum* until it was discovered that single eggs were being laid by this species. Could it be that some of those egg masses really were *A. jeffersonianum*? It would be enlightening to know whether females that lay egg masses and females that lay single eggs do so consistently year after year, or for that matter, even during the deposition of one year's complement of eggs.—SHERMAN BLEAKNEY, *National Museum of Canada, Ottawa, Ontario.*

ADDITIONAL RECORDS OF THE FOUR-TOED SALAMANDER, *HEMIDACTYLIUM SCUTATUM*, FROM NOVA SCOTIA.—Recently Bleakney (1953, *COPEIA* (3): 180) discussed the three known records of the four-toed salamander from Nova Scotia. Because the records were widely separated it was suggested that the species probably is relatively common in southeastern Canada. The collection of five additional specimens in 1955 further strengthens this suggestion.

Three specimens were taken by Mr. Francis Cook on June 3 when he visited the small boggy pond where the 1934 specimen was discovered in the city of Halifax. The habitat is now encompassed by railway yards, a paved highway and a cemetery. Removal of the moss on a log at the water's edge revealed two female *Hemidactylium scutatum* with their eggs. The two clutches contained a total of 36 eggs.

Mr. Cook's third specimen was found under a piece of bark on the shore of McGill Lake, near Albany Cross in eastern Annapolis County, and is a new locality record.

The other two specimens were collected by the senior author on June 27 in western Annapolis County. The site is the boggy outlet stream of Long Lake on top of the North Mountain near Bridgetown. This is the first record of the four-toed salamander from the north side of the Annapolis Valley. The specimens were found about fifty feet apart in sphagnum moss covering two logs that jutted over the stream. One was a male and the other a female

with 23 eggs. The digits of the larvae in the eggs were apparent and their yolk sacs completely absorbed indicating that they were about to hatch.—SHERMAN BLEAKNEY AND FRANCIS COOK, *National Museum of Canada, Ottawa, Ontario,* and *Nova Scotia Museum of Science, Halifax, Nova Scotia.*

TWO ERYTHRISTIC *PLETHODON CINEREUS* FROM NOVA SCOTIA.—The occurrence of erythristic individuals of the red-backed salamander has recently been reviewed by Reed (1955, *Copeia* (3): 253–4). His records are from the northeastern United States. We can now report the capture of two adult specimens of this color phase from Nova Scotia.

The specimens were collected August 16 by Francis Cook and were found beneath the stones of a rocky section of the shore line of Sandy Lake, a small lake on North Mountain north of Paradise, Annapolis County. Three specimens with typical red-back pigmentation were collected together with the erythristic individuals.

The two salamanders are similar in pigmentation. The basic orange-red color of the dorsal and lateral surfaces of the trunk and limbs has dark flecks scattered over it. On the head the flecks are in contact and produce a mottled effect. The bright color of the trunk extends onto the proximal dorsal surface of the tail, the remainder of the tail is dark grey. The ventral surface from chin to vent is cream colored with about ten dark flecks scattered along it. The specimens are 92 mm. and 85 mm. in total length; both are 45 mm. from snout to vent.

Of the more than 250 specimens of *Plethodon cinereus* examined from Nova Scotia by the senior author, only the two individuals were erythristic.—SHERMAN BLEAKNEY AND FRANCIS COOK, *National Museum of Canada, Ottawa, Ontario,* and *Nova Scotia Museum of Science, Halifax, Nova Scotia.*

A SNAPPING TURTLE, *CHELYDRA SERPENTINA SERPENTINA*, CONTAINING EIGHTY-THREE EGGS.—On July 5, 1954, a large female snapping turtle (carapace length 14¼ inches) was brought to the National Museum by Norris Denman. It was found crawling on a gravel parking lot at Knowlton Landing on the west shore of Lake Memphremagog in southern Quebec. Presumably it was searching for a nesting site.

The turtle was kept in captivity until July 21 when it was dissected. There were 44 fully formed eggs in the right oviduct and 39 in the left, a total of 83 fully formed eggs. A cursory survey of the literature indicates this is a record number of eggs for this species.

Norris-Elye (1949, Canadian Field-Nat. 63) reported snapping turtle egg clutches of 77 and 80 eggs from Manitoba. This Quebec record of 83 eggs is further evidence that the discovery of snapper nests containing large numbers of eggs does not necessarily indicate a communal nest.—SHERMAN BLEAKNEY, *National Museum of Canada, Ottawa, Ontario.*

A NEW SIZE RECORD FOR *THAMNOPHIS MARCIANUS* BAIRD AND GIRARD.—On July 31, 1955, a large female checkered garter snake (*Thamnophis marcianus*) was taken 3 miles north-northeast of Winterhaven, Imperial County, California. The overall length of this specimen was 1088 mm. (42½ inches) and the snout-vent length, 978 mm. (35¾ inches). This length considerably exceeds the largest record given by Van Denburgh (1922, Occas. Papers Calif. Acad. Sci., 10: 850) as 728 mm. (snout-vent length, 574 mm.) and the maximum size stated by Woodin (1950, Herpetologica, 6(2): 40) as "about 2 feet" and "29 inches or more" respectively.

The coloration, pattern and head scutulation of this specimen is typical. The dorsal scale rows number 21-21-17. A count of 208 combined ventrals and caudals is below the minimum extreme of 213, as given by Mittleman (1949, Bull. Chicago Acad. Sci., 8(10): 238) for western females, but it does fall within the range of 207–239 given for eastern females. It should be pointed out that the reduction of scales in this particular specimen is limited to the caudals, which number only 50 as compared to the minimum of 62 in western females examined by Mittleman (op. cit., 237). There is no indication that an injury to the tail has reduced its length.

Other specimens in the UCLA collection from Belen, Valencia County, New Mexico (UCLA 4544); 7.6 miles south of Tucumcari, Quay County, New Mexico (UCLA 4545) and from 1.5 miles south of El Major, Baja California, Mexico (UCLA 5508) fall well within the scale characteristics for western individuals as defined by Mittleman's study.

This snake was captured at 9:50 AM while it was swimming in about 4 inches of water in an irrigation ditch. The ditch was steep-sided, about 7 feet in depth and bordered by a dense growth of brush, weeds, rushes and grasses. The surrounding area was the cultivated drainage basin of the Colorado River delta, a typical habitat for this species. On the basis of the locality record alone it may be assigned to *Thamnophis marcianus nigrolateris* Brown. Temperatures taken at the time of capture were: body (cloacal) 32° C., water 32° C., air (at one foot) 33.5° C. Both *Bufo woodhousi* and *Bufo alvarius* were observed in the same habitat.—JAMES L. VIAL, *Department of Zoology, University of California, Los Angeles 24, California.*

ANOTHER RECORD OF THE ATLANTIC LEATHERBACK, *DERMOCHELYS C. CORI-*

ACEA, NESTING ON THE FLORIDA COAST.—Judging from early accounts, the Atlantic leatherback once nested regularly on the Florida coast. However, during the last hundred years or so, there has been but one recorded instance of a breeding leatherback in the state. This was reported by the present authors (*in* Carr, 1952, Handbook of Turtles: 451–452, pls. 80–81). Recently another record has come to light.

On a night in July, 1955, local residents found a number of hatching *Dermochelys* on the beach and lawn in front of the Melaleuca Hotel, in Miami Beach, Dade County, Florida. The hotel proprietor caught ten of the little reptiles; neighbors to the right and left caught what was described as "a tubful." Most of the captives were liberated, but two were given to Mr. Craig Phillips, biologist on the staff of the Miami Seaquarium. Mr. Phillips brought the circumstance to our attention.

The nest was not located definitely, but was thought to have been at the base of a stone wall near the hotel. Although many of the young turtles were on the beach, and so probably found their way into the surf, others were crawling about over the lawn as though lost.

The two specimens given to Mr. Phillips were kept for a time in a small tank at the Miami Seaquarium. Here they constantly swam against, and bumped their noses on, the tank wall, apparently being incapable of adjusting to confinement. Mr. Phillips had made similar observations on captive adult leatherbacks. In contrast with *Dermochelys*, examples of *Caretta* and *Chelonia* soon learn to avoid bumping into a tank wall, and may be successfully kept in an aquarium.

Mr. Phillips also called to our attention a hitherto unnoticed anatomical peculiarity of the very young leatherback. In the hatchling the tail is rudder-like, being rounded below but with a relatively high, thin keel above. By way of contrast, in cheloniid hatchlings the tail is very small and subcircular in cross-section. The keel on the tail of the young *Dermochelys* seems to be lost quite early in life, for in specimens of about five inches in carapace length the caudal appendage is bluntly ridged above but not carinated.—E. Ross Allen and Wilfred T. Neill, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida.*

NOTES ON THE HABITAT OF THE SCINCOID LIZARD, *BRACHYMELES GRACILIS TAYLORI* BROWN.—Inasmuch as there has been no published information on the habitat of *Brachymeles gracilis taylori*, we present notes on the occurrence of this lizard about 4 to 7 kilometers west of Valencia, Negros Oriental Province, Philippines, at an altitude of from 1200 to 2500 feet. Individuals were found near the ground in the moist and loose humus inside the decaying bark of large tree stumps belonging to a species of the genus *Erythrina*. A number of these trees were felled in an area now planted to abaca (*Musa textilis* Nee). The bark was very loosely attached to the underlying wood, whose outer portions had been converted to humus. Thus, ample space was provided for the skinks between the bark and the undecayed part of the wood. Shoving the bark with a knife was enough to knock it down in strips. The lizard was also found in the original forest at higher elevation in loose and very moist soil, especially in depressions which were covered with a moderately thick layer of rotting leaves. Some of the individuals collected were found in the soil beneath rotting logs, or within the logs themselves. The temperature of the soil where the skinks lived on one occasion was found to be 21.3° C.

The species was identified by Dr. Walter C. Brown, Natural History Museum, Stanford University, Palo Alto, California, who described this form recently (1956, Breviora, Mus. Comp. Zool., 54: 1–19).—Angel C. Alcala and Alfredo Y. Reyes, *Department of Biology, Silliman University. Dumaguete City, Negros Oriental, Philippines.*

HYBRIDIZATION IN THREE SPECIES OF SPADEFOOT TOADS.—Blair (1947, Copeia (1): 67) reported the hybridization of spadefoots from 20 miles west of Saltillo, Coahuila, Mexico, with *Scaphiopus couchi* as the female and *S. hammondi* as the male parent. Cell division was observed and development proceeded to the neurula stage after the embryos died.

On May 11, 1954 a gravid female *couchi* was obtained from 17 miles south of Throckmorton, Throckmorton County, Texas. Some *hammondi* and *bombifrons* had previously been obtained from Crosby County, Texas, between Ralls and Post on Farm Road 211. Sperm suspensions from a male of each species were prepared and eggs of the *couchi* female were stripped into each. A third cross (*couchi* ♀ × *hurteri* ♂), which I know to give viable offspring, was made to test the viability of the eggs.

Cleaving eggs were observed in all three batches and on May 12, it was noted that more than 80 percent of the eggs in the *hammondi bombifrons* cross had stopped development. All batches had been spread in porcelain pans to avoid crowding. Of the eggs still living from these two crosses, a few had reached the tailbud stage (Rugh, 1948, Experimental Embryology). On May 13, more dead embryos were discovered and removed. The most advanced stage was the free-swimming larva. However, all these were observed to be anomalous. Some of the anomalies were in the form of inflated yolk sacs, and some were characterized by curved spines. By the morning of May 14, all the larvae were dead

in the crosses involving *hammondi* and *bombifrons* while the "control" cross was in the young tadpole (feeding) stage.

It is concluded that the *couchi* ♀ × *hammondi* ♂ and *couchi* ♀ × *bombifrons* ♂ crosses are probably prevented from complete development because of inviability of the zygote during the early embryonic stages. The results of Blair are thus confirmed with animals from different parts of their range.—AARON O. WASSERMAN, *Department of Zoology, The University of Texas, Austin, Texas.*

BEHAVIOR OF THE CUBAN LIZARD *CHAMAELEOLIS CHAMAELEONTIDES* (DUMÉRIL AND BIBRON) IN CAPTIVITY.—This remarkable species, comprising a monotypic genus related to *Anolis*, is widespread in Cuba but apparently nowhere abundant (Barbour and Ramsden, 1919, Mem. Mus. Comp. Zool. Harv., 47: 128). Considering its convergence with the true chameleonids of the Old World in at least two important characters (eyelids partly fused, head developed posteriorly into a casque), the behavior of *Chamaeleolis* should be a matter of interest, but nothing seems to have been recorded to date. During a trip to Cuba in 1953 the author was given a live adult male (length 338 mm) which had been captured by Mr. Robert Dressler at Mina Carlota, Las Villas Province, in native mountain forest. This individual was maintained in good condition for a period of nearly a year, spending part of this time in Cuba and Mexico and the remainder at Harvard University in the United States. Its behavior was strikingly chameleon-like and quite different from that of several species of *Anolis* (including the giant *A. equestris* Merrem) which the author has observed in captivity. It was very sluggish, even when freshly captured, and could be left on a laboratory table without much danger of its wandering far away; it would often remain in the same spot for hours or even days without changing its position. Only when confronted with food in the form of living insects would it show much activity, moving deliberately and without hurrying toward the prey until its head was about two inches away. Smaller insects, such as blowflies and mealworms, were picked up with a sudden forward and downward flick of the tongue. Larger insects, such as adult *Periplaneta* roaches, were usually seized with the mouth, although the tongue was typically extruded a short distance first and played an important part in manipulating the prey afterward. The eyes could be moved independently and were observed to follow two different objects moving on opposite sides of the head.

Several experimental attempts were made to provoke territorial or other aggressive behavior in this individual. A live male *Anolis equestris* and a cardboard model resembling a male *Chamaeleolis* were placed near it at various times, but neither elicited any overt response. On one occasion, however, the *Chamaeleolis* was seen to extend its dewlap without any apparent external stimulus; this structure was as well developed as in most *Anolis* and bright yellow in color. Body color was subject to much daily change, varying from light gray to dark brown.—EDWARD O. WILSON, *Biological Laboratories, Harvard University, Cambridge, Mass.*

FURTHER COMMENTS UPON THE WESTERN RANGE OF *SCAPHIOPUS BOMBIFRONS*.—A recent note by Vladimir Walters (1955, Copeia (3): 252–3) disagreed with my assumption (1953, Herpetologica, 9 (3): 127–8) that an individual, *Scaphiopus bombifrons* (AMNH 53058), supposedly from near Gila Bend, Arizona, was probably from Chihuahua, and stated the toad in question was indeed from the Arizona locality. Walter's conclusions should be rejected for several reasons. First, the Walter's collection was not tagged in the field, and I was informed by Charles M. Bogert (personal correspondence) that "the entire collection probably should have been discarded when it became apparent that the collectors counted on their memories to supply locality data." Second, Walters makes no mention of remembering the specimen at the time of capture. Third, there is not evidence that a correct identification was made at the time. Fourth, two (not one, as mentioned by Walters) *Scaphiopus h. hammondi* are stated to have been taken at the same time as the *bombifrons*. If so, these *hammondi* would also represent a considerable western extension of the range of the species. The probability of other collectors missing both these species is slight. Fifth, the supposed Arizona individual is similar to the Chihuahua material as mentioned in my earlier paper (*supra cit.*) and quite in contrast to material from Cochise County, Arizona. The individual may have been procured in New Mexico on the east side of the Cordilleran Divide.

I do not feel that Walters closely read my former paper as he states, "Since there is only one specimen from each locality, the significance of these differences cannot be satisfactorily evaluated." I did not say that I had seen three, as he states, but 40. I have contrasted these not only with specimens of *bombifrons* in the AMNH collection from Samalayuca, but with 20 additional specimens from Samalayuca and from Chihuahua, Chihuahua, in my own collection and at the University of Illinois. I will state further that a clear statistical difference is present between material from Arizona and that from the east side of the Continental Divide including Chihuahua, and that the populations have not been named because the differences are apparently clinal in nature.

It is difficult to follow Walters's adumbrations.

He feels I should have realized that *S. bombifrons* occurred on the road between Ajo and Gila Bend because it occurs in Cochise County. The Cochise localities are in the high, grassy Desert Plains Subclimax, closely affiliated with the grassy plains frequented by the species in the states to the east and north, and in Chihuahua to the south. On the other hand the Gila Bend-Ajo transect is in the low, dry, hot ecotone between the Colorado Desert and the Arizona Upland Desert, in the Lower Sonoran life-zone.

The Ajo area has been thoroughly and repeatedly collected not only by myself but by L. M. Klauber, Charles H. Lowe, Jr., Philip Smith, Charles M. Bogert, W. Leslie Burger, H. K. Gloyd, Max Hensley, and many others. *Scaphiopus bombifrons* has never been taken there. Until it is there is little alternative other than to reject this curious and highly improbable record that extends the range over 200 miles to the west, and is based upon a single, untagged specimen obtained under untenable conditions and so morphologically constituted that it can readily be identified with a population from another geographically remote region.—FREDERICK A. SHANNON, *Box 276, Wickenburg, Arizona.*

THE EFFECT OF SALINITY ON THE SURVIVAL OF LARVAE OF *BUFO MELANOSTICTUS* SCHNEIDER.

The ability of some amphibians to withstand brackish water is well-known and indicated, for example, in the name, *Bufo boreas halophilus*. The experiments described below give some information on the extent of this ability in the tadpoles of a toad normally found in fresh water.

In March 1955, several thousand newly-laid eggs of *Bufo melanostictus* Schneider were collected from a freshwater pond in the grounds of the University of Hong Kong and distributed in jars of filtered pond water. On the day following collection most of the embryos had developed to an early neurula stage at approximately 36 hours and from these 1,000 of the most uniform were selected, removed from the egg-string, and distributed randomly into batches of 50, each in 200 ml of filtered pond water. Appropriate amounts of 25 percent NaCl solution were then added to four of these batches to bring them to a concentration of 0.25, 0.5, 0.75 and 1.0 percent respectively, and a fifth untreated batch was set aside as a control. On subsequent days this procedure was repeated with the remaining batches.

The overall length of embryos or larvae in the treated and control series was measured daily for the first ten days and subsequently at two-day intervals. Measurements were made under a dissecting microscope against a half-millimeter scale, active

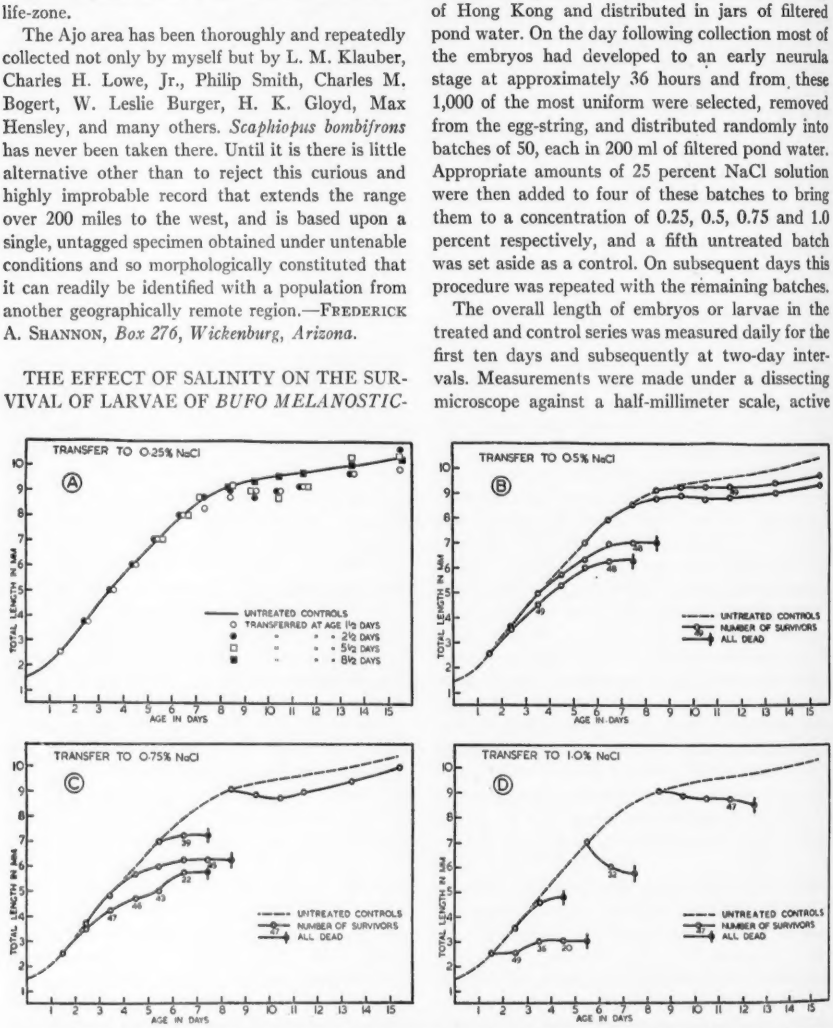

Fig. 1. Growth curves of tadpoles of *Bufo melanostictus* transferred to saline water at 1½, 2½, 5½ and 8½ days after fertilization. The heavy line in (A) and the broken line in the other graphs represent the growth of 4 batches of 50 individuals each maintained in fresh water. All other curves represent the growth of a batch originally of 50 individuals. Changes in the number surviving at each daily count are indicated. Growth curves of treated individuals are omitted in (A) because of their proximity to each other and to the "control" curve.

tadpoles being constrained in square-section Perspex pipettes for this purpose.

Tadpoles were fed daily on lightly-boiled lettuce leaves; the solutions were changed every three days. That these conditions were adequate is indicated by only two mortalities in the control batches (200 individuals), but subsequent tests have shown that a faster rate of growth would have occurred had there been less crowding.

From the body-length and survival data (Fig. 1) it can be seen that the ability to survive in brackish water is a function of age. For example (B, Fig. 1), individuals placed into water of 0.5 percent salinity at the age of 1½ or 2½ days became stunted and died, whereas at the age of 5½ or 8½ days they were only slightly retarded in their otherwise normal development. In a smaller test in which pairs of tadpoles with well-developed hindlegs were placed in the same range of salinities as in the foregoing experiment, metamorphosis was not significantly retarded after exposure for over two weeks to 0.75 percent saline and the tadpoles survived. After equivalent exposure to 1.0 percent saline, metamorphosis was retarded by several days and the toadlets failed to survive. Although the number of individuals is too small to warrant dogmatic conclusions, this is reasonable indication that the capacity to resist saline conditions continues to increase during larval life.

TABLE I

EFFECT ON THE DEVELOPMENT OF TADPOLES OF *Bufo melanostictus* OF TRANSFER TO INCREASED SALINITY

Age at transfer (days)	Salinity (% NaCl)	Effect	Age at death (days)
1½	0.25%	Unaffected.	—
	0.5%	Short tails, external gills very reduced.	7
	0.75%	Short bent tails with very reduced fins, external gills vestigial.	6–7
	1.0%	Tail buds fail to develop.	3–4
2½	0.25%	Unaffected.	—
	0.5%	Short tails, external gills reduced.	8
	0.75%	Short bent tails with reduced fins, external gills reduced.	7–8
	1.0%	Tailbuds shrivelled.	4
5½	0.25%	Unaffected.	—
	0.5%	Almost unaffected but reduced activity 4–6 days after transfer.	—
	0.75%	External gills shrivelled.	6–7
	1.0%	Tails shrivelled (see fig. 4). External gills shrivelled.	6–7
8½	0.25%	Unaffected.	—
	0.5%	Almost unaffected.	—
	0.75%	Almost unaffected.	—
	1.0%	Slight reduction of tail, very reduced activity. Undeformed at death.	12

The normal sequence of development in the control batches is 1½ days, early tail bud; 2, bending movements; 3, undulating movements; 3–6 external gills; 6½, right external gill resorbed; 7½, left external gill resorbed.

The effect of transfer from pond water of artificially increased salinity is summarized in Table I.

Probably every structure in the body of the embryo or tadpole suffers to a certain extent from dehydration when the individual is transferred from fresh water to a medium of higher salinity. These observations indicate that two of these structures are particularly sensitive, the tail and the external gills. Since each presents a large surface area, is thin-walled, and possesses a rich blood supply, this is not surprising. Transfer to high salinity at the neurula stage inhibits the formation of a tail bud or, if formed, may cause it to regress. In young tadpoles, the blood supply to the tail tip becomes occluded and the subsequent distortion of the tail (kinking and upward bending) may reflect a rearrangement of the blood supply rather than the direct effect of osmotic shrinkage. Whatever the cause, such deformed tadpoles are seriously impeded in their locomotion and it can be observed that this interferes with their feeding. The reduction of the external gills upon transfer to saline medium is very rapid, being noticeable in 1–2 hours.

It is tempting to attribute the described developmental failures to damage to the tail or gills but the results do not justify this conclusion. Irrespective of the age at transfer, the great majority of deaths occurred on the 6th to 8th day, that is, at the time of resorption of the external gills.—RONALD STRAHAN, *Department of Biology, University of Hong Kong, Hong Kong, B.C.C.*

RANGE EXTENSION OF THE SALAMANDER *PLETHODON VANDYKEI IDAHOENSIS*.—The Idaho subspecies of Van Dyke's Salamander has been known from only two small rock outcrops on the south shore of Wolf Lodge Bay on Coeur d'Alene Lake, Kootenai County, Idaho. A more widespread distribution in Idaho is indicated by the following recent collections.

On May 15, 1955 two females and two immatures were collected under moist moss on a stabilized talus slope on the south shore of Beauty Bay on Coeur d'Alene Lake (T49N, R3W, Sect. 11). The temperature of the substratum was 12°C.

One adult female and two immature specimens were collected October 17, 1955 under surface rocks at the mouth of an abandoned mine tunnel in Fourth of July Canyon (T49N, R1W, Sect. 17) approximately nine miles northwest of Cataldo, Kootenai County, Idaho. The substratum temperature was 10°C.

One adult female was collected October 17, 1955 under a small rock in a seepage in a fresh road cut on U. S. Highway 95 Alternate, five and one half miles southwest of Emida, Benewah County, Idaho (T43N, R3W, Sect. 13). The substratum temperature was 11°C.

On April 15, 1956 a single immature salamander was collected under wet moss in a small seepage on the south shore of Chatcolet Lake, one and one half miles south of Chatcolet, Benewah County, Idaho (T46N, R4W, Sect. 12).

These records extend the known range of *Plethodon vandykei idahoensis* approximately ten miles to the east and 40 miles to the south.—PHILIP C. DUMAS, *Department of Biological Sciences, University of Idaho, Moscow, Idaho.*

USE OF COPPER WIRE IN NOOSING LIZARDS.—In a joint study (Supported by the National Science Foundation) with Dr. Robert C. Stebbins of the Museum of Vertebrate Zoology on the parietal eye of lizards, we have made effective use of a noose of fine wire, a device not widely employed, to our knowledge, by herpetologists. We use American Standard Wire gauge size 34 (diameter 0.15 mm.) obtained from an electric cord by removing the insulation and separating one of the individual strands of wire. The wire should be clean and approximately 20 cm. in length. A small loop 2 mm. across is fashioned at one end of the wire by bending and twisting the tip. Through this loop the other end of the wire is passed to form a slip noose, the size of which can be easily and quickly adjusted by sliding the loop up or down the wire. The free end of the strand is attached to a light rod or pole about 150 cm. in length. To ensure rapid closure of the sling, kinks in the strand should be smoothed out and the plane of the loop placed at right angles to the wire. Extra strength can be obtained by entwining one or two additional strands of wire about the stem from the base of the opened noose to the pole. We have successfully used the device to capture *Sceloporus occidentalis, S. graciosus, Uta stansburiana, U. mearnsi, U. graciosa, Uma inornata,* and *Callisaurus draconoides.*

The copper-wire noose offers the following advantages over one of thread. 1. It remains open during use. 2. It does not whip about in a breeze. 3. Because of the wire's stiffness it can be maneuvered through brush, between and under rocks, and beneath the snout of an animal resting its head on rock or wood. 4. The angle of the noose can be adjusted as needed by appropriate bending of the stem at its attachment to the pole. From time to time the sling should be inspected for kinks which may weaken it and increase the likelihood of breaking. A new one can be quickly substituted. Adult *S. occidentalis,* struggling in mid-air, do not break an undamaged noose. Moreover, we have secured larger lizards (e.g. *Gerrhonotus multicarinatus* and *S. orcutti*) by allowing the snared animal to remain on the ground or in the brush and by playing it until it can be seized by an assistant or by the operator's free hand. The wire noose has the above advantages also in capturing small, light lizards, such as juvenile *Sceloporus,* providing the noose is no larger than necessary to slip easily over the head of the animal. For very small young, however, a noose of waxed thread (no. 100) attached to a short piece of wire or stick is superior.—RICHARD M. EAKIN, *Department of Zoology, University of California, Berkeley, California.*

RECENT COLLECTIONS OF THE CALIFORNIA LIMBLESS LIZARD, *ANNIELLA PULCHRA.*—Miller (1944, Ecol. Monog., 14: 271–9) and Stebbins (1954, Amphibians and Reptiles of Western North America) mention the geographic discontinuity of populations of the California Limbless Lizard (*Anniella pulchra*), and its doubtful occurrence on the floor of the San Joaquin Valley of California. Recent collections fill gaps in distribution, extend the range slightly, and allow comment on the biosystematics of the lizard. All specimens are in the author's personal collection.

An *Anniella p. pulchra* was taken December 26, 1954 at an elevation of 800 feet, 3.1 miles east of Paso Robles, San Luis Obispo County, California. The weather was cloudy with an air temperature (10 cm. above the soil, in the shade) of 4.4°C; the soil under the log (0.5–1.0 cm. below the surface) was 5.2°C, and the body temperature of the lizard, 7.8°C. The lizard was taken in a niche typical for the species. It tried to burrow swiftly when the log was turned.

Another individual was taken March 12, 1955, at 5900 feet elevation, about 1.75 miles northwest of Frazier Park, Kern County, California. It was in loose gravelly soil under a piece of decomposing granite lying on the south slope of a gully. The site was generally dry, especially the exposed soil, but there were a few slightly moist spots under some of the rocks. The sky was clear, the air (in the shade, 10 cm. above the soil), was 13.7°C., and the soil (0.5–1.0 cm. below the surface, in the open), was 8.5–8.8°C. The soil where the lizard was taken was 9.8°C, whereas the lizard was 11.8°C. Canyon Oak (*Quercus wislizeni*) was present.

I received a Limbless Lizard taken at an elevation of about 300 feet, and 9:30 p.m. on June 2, 1955, about 4 miles westsouthwest of Bakersfield, Kern County, California. It was crawling across a dark street intersection, near a cultivated yard of trees, shrubs, and grass, in an area where the uncultivated sections (one across the street) were of sandy soil and quite dry at this time. Another

TABLE I

MEASUREMENTS AND COLORS IN LIFE OF CALIFORNIA LIMBLESS LIZARDS IN THE COLLECTION OF THE AUTHOR.

Specimen	Locality (approximate)	Measurements			Pattern		Color		
		Snout-Vent	Tail	Ratio T/SV	Back	Belly	Back	Side	Belly
JG 941[1]	Paso Robles	121 mm	52 mm	.43	3 lines, side lines double from midbody	lines on body and tail			
JG 984	Frazier Park	125	24	.19	3 lines, side lines each of few fine lines	none			
JG 1119	Bakersfield	147	88	.60	3 lines, side lines double from midbody	none			
JG 1224	Glenville	142	85	.60	3 lines, side lines double	zigzag stripes, darker on tail	13E6	12H3	12C5
JG 1225	Glenville	142	80	.56	3 lines, side lines double	zigzag stripes, darker on tail	13F7	12J5	13E6
JG 1211	Tehachapi	151	78	.52	3 lines, side lines double to midbody	zigzag stripes, darker on tail	14B3	12K2	12 + L2
JG 1213	Tehachapi	146	76	.52	3 lines, side lines double to vent	zigzag stripes, darker on tail	13A3	13L5	13 + E5
JG 1214	Tehachapi	115	66	.57	3 lines, side lines double to vent	zigzag stripes, darker on tail	13F8	13L5	12E3
JG 1403	Kern River	146	80	.55	3 lines, side lines single	regular speckling			
JG 1404	Kern River	149	102	.68	3 lines, side lines single	regular speckling			
JG 1563	Havilah	88	40	.45	3 lines, side lines triple, then double to midbody	many fine, long lines			
JG 1571	Caliente	146	28	.19	3 lines, side lines double to midbody	very faint lines			

[1] Measurements of JG 941, 984, and 1119 on preserved specimens; the others were measured alive.

was found at this locality near a similar yard as it was crossing the street at least 500 yards from an uncultivated area.

Two other specimens were taken at 2600 feet on June 16, 1955, about 3 miles west of Glennville, Kern County, California. They were found under Blue Oak (*Quercus douglasii*) logs on a southfacing slope.

I found three individuals at 3900 feet, about 10:40 a.m. June 18, 1955, in a field beside U. S. Highway 466, 3.9 miles west of Tehachapi, Kern County, California. They were under the first of about 50 rocks turned. I saw the first when I turned the rock, the second as I scrabbled in the loose soil for the first which was burrowing quickly and the third, a much smaller one, as I dug for the second. At the site there were several hundred rocks and small boulders in a grassy field above the south bank of Tehachapi Creek. The soil temperature under the rocks (0.5–1.0 cm. below the surface) was around 19°C. (including the site of capture), and that of the air (in the shade, 10 cm. above ground) was 24.2°C; the day was clear and warm. I visited this site again on December 20, 1955 when the sky was partly cloudy and there was a slight southeast wind. The air temperature was 13.2°C, while the slightly damp ground under the rocks was 10.2–10.4°C. Despite a search of about triple the intensity of that of June 18, no lizards were found.

A specimen was collected March 4, 1956 on the north bank of the Kern River, 11.2 miles east-northeast of Bakersfield, Kern County, California. The day was cloudy and cool. On March 14, I visited this site, at an elevation of 1000 feet the animal was found under a sycamore log about 4 inches in diameter, lying on a small patch of sand surrounded by grass and about 32 by 64 inches in extent. It was about 40 yards from a group of 10 Western sycamores (*Platanus racemosa*), and about 90 yards west of one of several Blue Oak (*Quercus douglasii*). At this date and time, about 5:45 p.m., the air temperature 10 cm. above ground was 18.4°C. the slightly moist soil, 1 cm. below surface, was 19.2°C. About the same time another lizard was found. It's temperature was 17.8°C. while the soil, which was dryer, with a very slight trace of moisture, a very humus-dark, grainy soil, with some sand was 16.4°C. The animal was under a sycamore log at the east edge of the sycamore group, which was about 5 yards wide by 20 long. This was the only animal found in a series of about 250 pieces of cover turned over. The coloration of both animals taken here does not fit my recollections of the Tehachapi-Glenville specimens (see Table I).

On April 15, 1956, I took a small specimen 6.2 miles south of Havilah, Kern County, California. The area, about 3500 feet elevation, was an open field surrounded by Blue Oaks (*Quercus douglasii*). The animal was on coarse, moderately humus sand, under a small rock. There was only the faintest

suggestion of moisture in the soil where the temperature was 24.6°C. although the air was relatively cool, 16.8°C. This animal can be considered along with another one, an adult, collected about 2 miles north of Caliente, Kern County, California (elevation about 2000 feet). The dorsal coloration of both animals was a grayish-pink brown, with the smaller being slightly grayer (near shedding?). The ventral color of the adult was greenish-yellow, while that of the smaller was grayish-yellow. Both appeared much like the Tehachapi specimens.

Fig. 1 shows the locality records of *Anniella* (*p. pulchra*, *p. nigra*, and *geronimensis*) in the Museum of Vertebrate Zoology of the University of California, the Stanford (University) Natural History Museum, the California Academy of Sciences, and the herpetological collection, department of zoology, University of California at Los Angeles, along with several other localities mentioned in Miller (1944, (*supra cit.*), and the additional localities described herein. The Tehachapi site extends the range about 30 miles east.

The typical habitat seems to be slightly moist warm loose soil (mulchy sand) under trees, mostly oaks (coastal beach sites excepted), on a southfacing slope. The animals hide during the day but are sometimes found in the open at dusk or after dark. The temperatures I record here extend the threshold of field activity below that given by Miller (1944, *loc. cit.*; 284).

Two species, *Anniella pulchra* and *A. geronimensis*, are now defined by means of slight differences in body form, scalation, color, and pattern. Two subspecies, *A. p. pulchra* and *A. p. nigra* are defined by means of color and pattern. Table I gives measurements of the animals reported here, some measured alive, and some after preservation, with an approximate error of three percent. The patterns are briefly described. None of the lizards showed continuous areas of melanic color over a definite body area, as in *A. p. nigra*, except on the snout and at the tip of the tail. Such continuous melanic areas are found on the belly of some of the animals taken near Porterville, Tulare County, California. Melanic pattern, however, is usually available to the student in the preserved specimens whereas other colors may fade.

The color descriptions given emphasize the nonmelanic colors, and are specific colors from Maerz and Paul (1950, A Dictionary of Color, ed. 2). Colors in the living animals were determined at a northfacing window in clear midday in midsummer. The animals had been in captivity a few weeks. Nine color determinations were made on each animal, three each dorsally, laterally, and ventrally, at midbody, vent, and midtail. The determinations given in Table I are approximate "averages." It may be needless to suggest that the high degree of subjectivity in color determinations may make general systematic considerations based on color questionable.

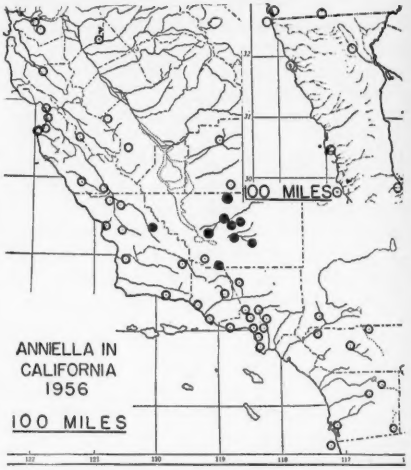

Fig. 1. Distribution of *Anniella*. The solid circles show the new localities reported herein. The open circles show localities based on specimens in other collections and a few reported by Miller (1944). The question mark indicates a doubtful locality record. *A. pulchra nigra* is in the northwest part of this range, intergrading with *A. p. pulchra* in Monterey County. *A. p. pulchra* and *A. geronimensis* are sympatric in the south part of the range (in Baja California, Mexico); both exist separately on islands off the peninsular west coast.

I thank Dr. Robert C. Stebbins of the Museum of Vertebrate Zoology of the University of California, Mr. Charles Miller of Los Angeles, and Mr. Charles Shaw of the San Diego Zoo for reading and advising me on this paper.—JOE GORMAN, *Biology Dept., St. Louis Univ., St. Louis, Missouri.*

RANA SYLVATICA LE CONTE IN IDAHO.—The presence of an isolated population of the Wood Frog (*Rana sylvatica*) in Colorado and Wyoming has suggested the possibility that this species may be found in the northern Rocky Mountain area between the Colorado-Wyoming population and the main body of the range of the species in Alberta, Canada. Stebbins (1951, Amphibians of Western North America: 373) has suggested that the Wood Frog ". . . probably occurs in western Montana". With this situation in mind it seems of value to report the presence of *Rana sylvatica* in Idaho.

A single adult female of this species was collected April 14, 1956 in a small pond by the Kootenai River approximately one mile west of Bonners Ferry, Boundary County, Idaho. The pattern and coloration were typical of the species.

An adult female, collected Aug. 2, 1955 on Lamb Creek, 2 miles east of Coolin, Bonner County, Idaho, appeared somewhat intermediate in character be-

tween *Rana sylvatica* and *Rana pretiosa*. This specimen had a snout-vent length of 58.5 mm. The dorsal background color was light grayish olive. A few elongate black spots were scattered between the prominent dorsolateral folds. The hind legs were indistinctly banded with black. A distinct, black, triangular patch extended from the ventral side of the shoulder to the inside of the elbow. A pronounced black mask extended from behind the tympanum, past the nostril, and almost to the upper lip. The snout was faintly marbled with black. The underside of the hind legs and toes and the lateral margins of the abdominal region were orange-pink.

These records suggest the presence of a population of *Rana sylvatica* in the northernmost counties of Idaho.—PHILIP C. DUMAS, *Department of Biological Sciences, University of Idaho, Moscow, Idaho.*

BAT PREDATION BY THE CUBAN BOA, *EPICRATES ANGULIFER* BIBRON.—Barbour and Ramsden (1912, Mem. Mus. Comp. Zool., 47 (2): 72–213) comment on the possibility of predation by the Cuban boa, *Epicrates angulifer*, on bats. Their account includes a comment by V. J. Rodriguez who described a narrow cave passage in which a large boa was making repeated lunges at passing bats. Barbour himself found numerous bat skeletons around the opening of a cave near Guanajay, but concluded that these animals had been killed by barn owls. Miller (1904, Proc. U. S. Nat. Mus., 27 (1359): 337–348) mentions a cave near Baracoa, the vertical entrance of which was choked with tree roots. According to local reports boas coiled themselves among these roots and seized bats leaving the cave. Recent observations on a large number of cave-dwelling *E. angulifer* have conclusively demonstrated bat predation by this species.

The cave studied, locally called Cueva de Majas (Cave of the Boas), is located about seven miles west of Trinidad in the eastern slope of the Guanayaro River Valley, Las Villas Province, Cuba. Its entrance penetrates the face of a limestone ridge which extends for several miles along the river.

The cave is approximately 150 yards long and consists of five rooms, each occupying a different level. The entrance is broad and steep and extends beneath a thick limestone ledge. The base of the entrance flares out into a small rock-strewn entrance room. To the right of this room several short passages lead over fallen rocks into a small second chamber. At the extreme left of the entrance room a wooden ladder leads down a fifteen foot ledge giving access to the third and largest room of the cave. To the left this chamber terminates at an opening two feet wide from which a ladder extends to the floor of the fourth chamber. The third chamber continues to the right ending at a large opening through which a muddy slope leads to the fifth and final chamber. Besides the boas, a large colony of the bat *Phyllonycteris poeyi* occupies the cave, being most abundant in the fourth and fifth chambers. Apparently this is the only species of bat living in the cave. Other animals observed in the cave included the American roach, *Periplaneta americana*; a number of land crabs, *Gecarcinus ruricoli*; several common rats, *Rattus norvegicus*; the click beetle, *Pyrophorus noctilucus*; and a single Cuban tree frog, *Hyla septentrionalis*, found at the extreme end of the cave.

Observations were made at the cave between December 22–24, 1954 and September 8–12, 1955. Two visits were made each day, one between 2:00 and 4:00 PM and the other between 7:00 and 10:00 PM.

Forty-one boas, ranging in length from four to eight feet, were collected. Thirty-five of these individuals were found in the immediate vicinity of the narrow passage leading from the third to the fourth chamber. Five were taken from the entrance room, and one from the extreme end of the fifth chamber. None was observed in the second chamber or on the floor of the fourth. A large shelving rock is situated at the top of the ladder connecting the third and fourth chambers. Snakes could be seen during the afternoon visits wedged far back beneath this rock.

Although some of the cave visits lasted several hours, most of the snakes were collected within fifteen minutes after entrance. A definite correlation between reptilian activity and bat movement was observed. Snakes were rarely seen during the afternoon, but were moving about freely, generally in the third chamber or on the ladder and ledges descending from it, during the evening emergence of bats. The sequence of captures was as follows:

	Afternoon	Evening
December 22, 1954	2	7
December 23, 1954	1	5
December 24, 1954	0	7
September 8, 1955	? (no visit made)	4
September 9, 1955	0	6
September 10, 1955	2	2
September 11, 1955	0	2
September 12, 1955	0	0

Three of the snakes, collected during evening hours beside the opening leading from the third to the fourth chamber were constricting or swallowing bats when captured. The digestive tracts of two others were emptied by forced regurgitation and found to contain, respectively, three and nine bats. Several bat skeletons were found on the ledge inside the opening to the fourth chamber.

The data now at hand strongly suggest that *Epicrates angulifer* captures bats by striking at them as they fly through constricted openings in the

caves. If this is the general method of capture, the sensory perception involved presents an interesting problem in reptilian behavior worthy of future study.

Occasionally the carcasses of young bats are found on the cave floor. It is not improbable that the snakes also prey on bats roosting in accessible areas. This method of capture has been suggested in the case of the bat predator *Elaphe guttata emoryi* by Twente (1955, Jour. of Mamm., 36 (3): 379–390).

Assistance in the field by Billy S. Batts, of North Carolina State College, Raleigh, North Carolina, and Daniel Lyons, of the Natural History Society of Maryland, Baltimore, Maryland, is greatly appreciated.—JERRY D. HARDY, JR., *Department of Zoology, University of Maryland, College Park, Maryland.*

THE EASTERN MUD SALAMANDER, *PSEUDOTRITON MONTANUS MONTANUS*: A NEW STATE RECORD FOR NEW JERSEY.—The purpose of this paper is to add *Pseudotriton montanus montanus* Baird to the herpetofauna of New Jersey and to comment briefly upon the distribution of this salamander. In a sense, the late Emmett Reid Dunn should have been a coauthor. I took the living New Jersey specimen, the first from that state, to him at once to verify its identification, and together we subsequently examined all *Pseudotriton* material from the general region in the collections of the Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, and in my personal possession. This was done in an unsuccessful effort to find an additional *montanus* that might have been catalogued as a *ruber*. Despite his long and fruitful preoccupation with Neotropical herpetology, Dr. Dunn's interest in the family Plethodontidae continued unabated, and his last professional act was to examine some specimens of *Pseudotriton* that I took to his hospital room a short time before his death.

The New Jersey *montanus* was caught on August 3, 1953, by A. L. Cramer, of Marlton, N. J., at the edge of a fallow cranberry bog. During the course of reopening a ditch that had become overgrown with vegetation, Mr. Cramer turned a shovel full of mud and discovered a red "lizard" crawling out of it. In Mr. Cramer's company, I visited the locality a day or two later. It is a typical small cranberry bog, much like the many others that dot the Pine Barrens region of southern New Jersey, and it is surrounded by woods dominated by *Pinus rigida*. The locality is approximately three and one-half miles south-southeast of Marlton, Burlington County, and it lies within, but very close to the western edge of, the Pine Barrens. The specimen (now AMNH A59821) is a male measuring 121 mm. in total length; it has 17 costal grooves. The familiar external *montanus* characters are all present: relatively few discreet, rounded black dorsal spots, a dorsal "ground color," and a short eye-to-snout length. The iris of the eye was brown in life. The specimen will be illustrated in color in our forthcoming *Field Guide to the Reptiles and Amphibians*.

Another specimen of *montanus* recently presented to me by Joseph M. Bauman, of Wilmington, Delaware, would, in itself, have constituted a range extension of some interest. This was taken in a small stream with a muddy bottom at the northern edge of the town of New Castle, New Castle County, Delaware, on March 26, 1956. This salamander (now AMNH A59822) is a female measuring 102 mm. in total length; it, too, has 17 costal grooves. The nearest previously published record for Delaware is in Sussex County (Conant, 1945, Delmarva checklist, Soc. Nat. Hist. Delaware: 3) some sixty-five miles to the south. James A. Fowler has taken it near Price, Queen Annes County, Maryland, however, which is approximately forty-five miles southwest of the New Castle locality.

The presence of *montanus* so far north in Delaware and so close to the Delaware River suggests that it may be found eventually in the Coastal Plain of southeastern Pennsylvania—if the bulldozer and the pollution of the industrial age haven't already exterminated it in that area. Similarly, *montanus* may also occur in small mud-bottomed streams on the New Jersey side of the river. Considering its propensity for a muddy habitat, finding *montanus* in the sandy Pine Barrens, instead of in the region of clayey soils immediately to the west, is somewhat of a surprise. On the other hand, *Pseudotriton ruber ruber* is the most frequently encountered salamander in the Barrens, being known from several more localities than *Plethodon cinereus cinereus*, the next most common form. A specimen of *ruber* from the Barrens shows that this species occasionally may have a brownish eye similar to that which is nearly universal in *montanus*. This is attested by a kodachrome slide made by Kenneth L. Gosner, of the Newark (N. J.) Museum, of a living specimen from Webbs Mill, Ocean County, in which enough brownish pigment is present to obscure to a considerable extent the normal bright yellow iris of *ruber*. The specimen, now preserved and 87 mm. in total length, is otherwise typically *ruber*.

Both of the new localities reported above for the Mud Salamander are from the Coastal Plain, and they help emphasize the conclusion of Fowler (Copeia, 1941: 181) and Hoffman (Herpetologica, 4: 68) that *montanus* is essentially a lowland animal in the Northeast despite its specific name. All their records are from the Coastal Plain or the outer edge of the Piedmont. Generations of herpetologists have sought the species in vain at the type locality, South Mountain, near Carlisle, Pennsylvania, from which

it was described by Baird in 1849 (Journ. Acad. Nat. Sci. Phila., 1: 293). No other specimen of *montanus* has been collected in Pennsylvania despite the very extensive field work of M. Graham Netting, Neil D. Richmond, and others in carrying forward the herpetological survey of the Keystone State. Two other specimens, reported from upland areas, need verification before their data may be fully accepted. The American Museum of Natural History has a *montanus* (AMNH 1701) from Orangeburgh, Rockland County, New York, that was listed by Dunn (1926, Salamanders Family Plethodontidae: 290). Charles M. Bogert, who, at my request, recently checked the data accompanying this specimen, suggests that it be discounted unless confirmed by other evidence. Another specimen, said to have been taken in the Catoctin Recreational Area, Frederick County, Maryland, was presented to Charles J. Stine, Jr., of Baltimore, and is now in his private collection. Dr. Stine and James A. Fowler subsequently visited the locality and found numerous *ruber*, but no habitats that they deemed suitable for *montanus*.

This salamander may still occur in the midst of the Piedmont or Blue Ridge in the northern part of its range, but it must be rare, highly localized in distribution, or both. Dunn (*op. cit.*: 27–8) suggested that perhaps the scarcity of *montanus* toward the north might result from competition with, and replacement by, *ruber*. This may be true in upland localities, but recent field work has shown that *montanus* is not rare in the Coastal Plain of Virginia and Maryland and on the Delmarva Peninsula. The two species have been found together or virtually together in several localities within this lowland area.

Whatever its range may be in the Northeast, *montanus* is widespread through the uplands in the South, occurring from virtually the Atlantic coast to the Blue Ridge Province. Dunn (*op. cit.*: 288) mapped several localities for the Piedmont and mountainous portions of the Carolinas, and its presence in that general area has been amply verified by recent collecting. Albert Schwartz has an abundance of upland records for it in South Carolina (ms. map); Joseph R. Bailey has taken it in the Swannanoa River Valley, near Swannanoa, and Schwartz has a specimen from Swain County (personal communications), both localities being in western North Carolina. Martof (1956, Amphs. Repts. Georgia: 70) reports *montanus* from northeastern Georgia.

In summary, the known and verified localities for *Pseudotriton montanus montanus* indicate that this salamander is almost limited to the Coastal Plain and the extreme outer edge of the Piedmont in the northern part of its range, the only exceptions being the type locality in the Blue Ridge Province near Carlisle, Pennsylvania, from which it may now have disappeared, and the unsubstantiated New York and Maryland records. Toward the south, *montanus* enters the uplands; it is widely distributed through the Piedmont and occurs, at least sparingly, in mountain valleys of western North Carolina.

Grateful acknowledgement is made to Joseph R. Bailey, Charles M. Bogert, Doris M. Cochran, James A. Fowler, Kenneth L. Gosner, Bernard S. Martof, Albert Schwartz, Charles J. Stine, Jr., Charles F. Walker, and especially the late Emmett Reid Dunn for information incorporated in this paper.—ROGER CONANT, *Zoological Society of Philadelphia, Philadelphia 4, Pennsylvania.*

Ichthyological Notes

SOUTHERN EXTENSION OF THE KNOWN RANGE OF THE BASKING SHARK, *CETORHINUS MAXIMUS* (GUNNERUS).—On 16 February 1955 Mr. J. C. Brown, a fisherman at Mayport, Florida, reported that he had caught a large, strange fish in his shad net which had been set in approximately six feet of water just below the south Mayport jetty (Mayport is on the Atlantic coast of Florida almost due east of Jacksonville). The fish, a young female basking shark, was taken to Marineland by truck to be weighed, measured and photographed. In coloration the shark was dark gray above, shading to a somewhat lighter gray dorsolaterally. An irregular light line along each side demarked what appeared to be an overlapping of the darker dorsal pigmentation onto the lighter colored lower sides.

The following figures designate per cent of total length (snout to base of caudal plus length of upper caudal). All measurements were straight line distances to the nearest half-inch. Total length 121.5 inches (3683 mm). Snout to: outer nostrils, 6.2; spiracle, 13.8; fifth gill slit, 26.1; first dorsal, 37.6; second dorsal, 64.8; upper precaudal pit, 76.5; pectorals, 24.7; pelvics, 52.4; anal, 65.5.

Eye, horizontal diameter, .86; nostrils, distance between inner ends, 3.3; mouth, breadth, 10.3; upper precaudal pit, width, 1.7.

First dorsal fin, vertical height, 9.7, length of base, 8.3; second dorsal fin, vertical height, 3.5, length of base, 2.8; anal fin, vertical height, 2.4, length of base, 2.4; caudal fin, upper anterior margin, 23.2, lower anterior margin, 11.4; pectoral fin, outer margin, 15.4, inner margin, 13.8, greatest width, 6.9.

Origin to origin: 1st and 2nd dorsals, 27.2; 2nd dorsal and precaudal pit, 11.7; pectoral and pelvic fins, 27.6.

According to Bigelow & Schroeder (1948, Fishes of the Western North Atlantic, 1: 154) *Cetorhinus maximus* is an inhabitant of temperate-boreal waters. Of previous southernmost records for the western North Atlantic, one was reported by Coles (1915, Proc. Biol. Soc. Wash., 28: 92) who observed a large shark "of a length in excess of 40 feet" lying motionless at the surface off Cape Lookout, N. C., in July, 1905. Although this fish was not positively identified it may well, in view of its size and behavior, have been a basking shark. The other southern record was reported by Brimley (1935, Jour. Elisha Mitchell Soc., 51: 311) who told of the capture on February 12, 1935 of a female basking shark taken in a shad net about two miles outside Corncake Inlet, N. C. This specimen was 13 ft. 5 in. from tip of snout to tip of tail and was estimated to weigh about 600 lbs. The Mayport specimen consequently extends the known southern range of the basking shark by some 300 miles.

I am obliged to W. C. Schroeder, Museum of Comparative Zoology, for excerpts from the references cited, which were not available to me.—F. G. Wood, Jr., *Marineland Research Laboratory, Marineland, Florida.*

DISTRIBUTIONAL AND NOMENCLATORIAL NOTES ON THE SUCKERS OF THE GENUS *MOXOSTOMA*.—In the course of revisionary study of several species groups in *Moxostoma* some items of nomenclatorial and distributional interest have been noted for species with which we were not directly concerned. These items are discussed herein. We gratefully acknowledge Royal D. Suttkus of Tulane University for the loan of specimens and Leonard P. Schultz, Ernest A. Lachner and Robert H. Kanazawa for providing working space and access to the collection at the United States National Museum.

M. valenciennesi.—We identify with this species (= *M. rubreques* Hubbs) a specimen 81 mm. in standard length (USNM 68215) collected in the Maple River, North Dakota, by A. J. Woolman in 1892. Woolman (1895, Rept. U. S. Comm. Fish and Fisheries for 1893: 343–373) does not list any *Moxostoma* from Maple River but does record *M. macrolepidotum duquesnii* (*sic*) from other tributaries and the Red River itself. This record is apparently based in part on *valenciennesi* and, on the basis of the specimen listed above, this species may be added to the known fauna of the Red River and North Dakota.

M. carinatum.—Two specimens (TU 2051), 72 and 78 mm. in standard length, from the Pearl River, six miles east of Varnado in Washington County, Louisiana, indicate that the little known river redhorse enjoys a more extensive southern distribution than was formerly believed; it is to be expected through the lower Mississippi River System and other Gulf rivers as far east as the Pearl. Numbers of fin rays and scales for these two specimens may be summarized as follows (number of specimens or fins in parentheses): dorsal rays: 13 (2), anal rays: 7 (2), pelvic rays: 9 (4), pectoral rays: 16 (1), 17 (3), lateral-line scales: 42 (1), 43 (1), scales around the caudal peduncle: 5-2-5 (2). Both have the upper lobe of the caudal fin produced, a black whorl at the edges of the small scales on the base of the caudal fin, black scale bases, and enlarged pharyngeal teeth; all are features of *carinatum*.

Comparison with material collected by S. E. Meek in the Arkansas and White river systems shows no essential differences although Meek's material frequently has 10 rays in the pelvic fin; nine are consistently noted elsewhere in the range of *carinatum*. The following Arkansas material was examined (number of specimens and standard lengths in parentheses): USNM 61920 (1, 79), USNM 62030 (2, 130–139), USNM 62031 (1, 144), USNM 62032 (1, 86). The data may be summarized as follows: dorsal rays: 12 (1), 13 (4); anal rays: 7 (5); pelvic rays: 9 (5), 10 (5); pectoral rays: 17 (9), 18 (1); lateral-line scales: 42 (3), 43 (1), 44 (1); scales around the caudal peduncle: 5-2-5 (5). Probably on the basis of 10 pelvic rays, *carinatum* was often confused with *duquesnei*. Meek (1895, Bull. U. S. Fish. Comm. for 1894, 14: 76) noted that *duquesnei* and *carinatum* are very similar but his mixed samples for specimens from Village Creek labelled *duquesnei*, are identified by us as *carinatum*.

M. aureolum.—Girard (1856, Proc. Acad. Nat. Sci. Philadelphia, 8: 8–9) described *Ptychostoma haydeni* from specimens taken in the "Yellow Stone River, by Dr. F. V. Hayden, and in the Missouri River at Fort Pierre, by Dr. John Evans." Jordan and Copeland (1877, Bull. Buffalo Soc. Nat. Sci., 5: 157) listed it as "*Teretulus haydeni* (Grd.)" with the range "Upper Missouri River". Jordan (1878, Bull. U. S. Nat. Mus., 12: 101) listed *Ptychostomus haydeni* in his table of nominal species and identified it with *Minytrema melanops*. He discussed this action further under *Minytrema melanops* (Jordan, *op. cit.*: 139). "Later, Dr. Girard described and figured Texan specimens without the lateral line under the name *Moxostoma victoriae*, and specimens

with the lateral line from the Upper Missouri Region as *Ptychostomus haydeni*. The types of neither of these species are preserved. . . ." Jordan (1885, Proc. U. S. Nat. Mus., 8: 120) identified *haydeni* with *M. macrolepidotum* with some question. Jordan and Evermann (1896, Bull. U. S. Nat. Mus., 47 (1): 187) again listed *P. haydeni* as a synonym of *M. melanops* and recorded the type as USNM 20263.

This specimen was located among the unidentified *Moxostoma* in the National Museum. The label reads "S. Pac. R. R. Survey, Gov. Stevens." A secondary label states that it is "supposed to be the type of *Pt. haydeni* but = *M. aureolum*." In addition the pharyngeal teeth, which had been removed, are cataloged in the skeletal collection as no. 172 and bear the data "Yellowstone, Upper Missouri, coll. by Hayden." The specimen agrees well with Girard's description which, unfortunately, is not diagnostic. The very full and plicate lower lip is quite unlike that of *Minytrema*. The lateral line is fully developed and the air bladder is three-chambered. The suborbital bones are narrow. The specimen is clearly to be identified with *M. aureolum* and there is no reason to doubt that it is the type of *haydeni*. *P. haydeni* should be removed from the synonymy of *Minytrema melanops* and placed in that of *Moxostoma aureolum*.

Cope and Yarrow (1875, Geol. and Geog. Explor. and Surv. west of 100th meridian, U. S., Chap. 6: 680) provisionally referred three specimens, collected by Dr. J. T. Rothrock at Ash Creek, Arizona (in the Gila River System) during July, 1874, to *Ptychostomus congestus* Girard (= *M. congestum*). Jordan (1878, Bull. U. S. Geol. and Geog. Surv., 4 (2): 417) apparently used this record as a basis for recording *Myxostoma macrolepidotum* (in itself misused by writers of this period for a combination of several species) from Arizona. Jordan (1887, Rept. Comm. Fish and Fisheries for 1885: 807) noted that ". . . the specimens from Ash Creek, Arizona, referred with doubt to this species" (i.e., *congestum*) ". . . by Cope and Yarrow . . . belong apparently to *M. congestum*." Jordan and Evermann (*op. cit.*: 187) wrote of *congestum* "said to have been taken in Ash Creek, Arizona, but this is doubtful."

The three specimens in question are at the National Museum. The data follow: USNM 16755 (3, 183–196 mm. in standard length); dorsal rays: 13 (3); anal rays: 7 (3); pelvic rays 9-9 (3); pectoral rays: 16-17 (2), 17-17 (1); lateral line scales (40 (1), 41 (2); scales around the caudal peduncle: 5-2-5 (3). Although faded, the specimens are firm and in good condition. The dark spots at the bases of the scales on the upper part of the body may still be seen. The lips are plicate and the two lobes of the lower lip meet at an obtuse angle. The interradial membranes of the dorsal, caudal and anal fins do not have dark slashes.

These specimens are not to be identified with *M. congestum* or with any other species of the subgenus *Scartomyzon* (see Robins and Raney, 1956, Cornell Univ. Agr. Exp. Sta. Mem. 343: 5) but rather with *aureolum*. This species ranges far to the west in the Missouri River System of Montana and Wyoming, the North Platte System of Wyoming (Simon, 1946, Wyo. Game and Fish. Dept., Bull. 4: 62) and in streams of eastern Colorado (Beckman, 1952, Univ. Colo. Mus., Leaflet 11: 30). The distributional record from Ash Creek must be considered in error since no species of *Moxostoma* is known from the area west of the Continental Divide and north of Mexico.

M. macrolepidotum.—Extralimital records that cannot be repeated provide disturbing problems for students of distribution. This is especially true when the species is common and easily taken in its normal range. Such a record is that of the spotted sucker, *Minytrema melanops*, from Chesapeake Bay. Hildebrand and Schroeder (1928, Bull. U. S. Bur. Fish. for 1927, 43 (1): 118) gave an extensive account of the specimens on which their unique record is based. They were apparently misled by not realizing that dark scale bases characterize several species of *Moxostoma*, notably those allied to *aureolum* (*breviceps*, *macrolepidotum* and *coregonus*), as well as *Minytrema*. In many specimens the dark scale bases produce a spotted pattern not unlike that noted in *Minytrema melanops* although the spots are less discrete. The specimens on which the Chesapeake record is based, USNM 127221 (1, 323 mm.) and USNM 90698 (4, 67–70 mm.), were collected near Havre de Grace, Maryland, and are referrable to *Moxostoma macrolepidotum*, a form found in most tributaries of the Bay. *Minytrema* has not been noted by us north of the tributaries to Albemarle Sound, North Carolina. The distinctness of *macrolepidotum* from *aureolum* is questionable but further comment on their relationship is beyond the scope of this paper.—Contribution 163 from The Marine Laboratory, University of Miami. C. RICHARD ROBINS, *The Marine Laboratory, University of Miami, Coral Gables, Florida* AND EDWARD C. RANEY, *Department of Conservation, Cornell University, Ithaca, New York.*

RECORDS OF SOME GULF OF MAINE FISHES.—*Carcharodon carcharias* (Linnaeus); Great white shark. On August 9, 1955, Ted Farrin, operator of a floating fish trap, caught a 309.9-cm. male great white shark at Pemaquid Point, Lincoln County, Maine. The specimen was sent to a Boston, Massachusetts fish market to be sold as fresh shark meat.

Mugil cephalus Linnaeus; Striped mullet. A 7.5-cm. specimen was caught at Sams Cove, Muscongus Bay, Lincoln County, Maine on September 16, 1955. The fish had been trapped in a tide pool behind a fence designed to bar green crabs (*Carcinides maenas*) from intertidal clam beds.

Sarda sarda (Bloch); Atlantic bonito. A 46.4-cm. specimen was caught in Maurice Pye's floating fish trap at Small Point, Sagadahoc County, Maine on July 9, 1954. According to Maine fishermen who use these traps at Pemaquid Point and Casco Bay, a dozen or so bonitos have been caught each summer for several decades. This species is much less common in the northern Gulf of Maine than in the southern (Bigelow and Schroeder, 1953, U. S. Fish. Wildl. Fish. Bull., 74: 338).

Hippocampus hudsonius DeKay; Seahorse. There female specimens have been caught while attached to Maine lobster trap buoy lines. One with a length of 9.5-cm. was found October 18, 1953, near Pumpkin Ledges, off Boothbay Harbor, Lincoln County. Another, 10.8-cm. long was taken during the same month near Kennebunk, York County. The third fish, measuring 12.8-cm., was caught October 18, 1956 at Southport, Lincoln County.

Naucrates ductor (Linnaeus); Pilotfish. During the last week of August 1949, fish trap operators at Barnstable, Massachusetts, caught a 27-cm. pilotfish in Cape Cod Bay. The local fishermen considered this an unusual fish and were not able to identify it.

Pseudopriacanthus altus (Gill); Short big-eye. On September 2, 1956, Herbert Decker of Southport, Maine, found a 2.8-cm. specimen in a lobster trap hauled up from a depth of ten fathoms. This is the first record for this fish on the Maine coast. The body color in life was orange red; the spiny dorsal fin had two rows of orange spots, two on each spine; the ventral spine had two orange spots; the iris had four white spots; and immediately above the lateral line was a row of 12 black blotches. This specimen was similar to one mentioned by Hildebrand and Schroeder (1928, Bull. U. S. Bur. Fish., 43 (1): 255), for it had two enlarged spines at the angle of the preopercle.—Leslie W. Scattergood and Gareth W. Coffin, *U. S. Fish and Wildlife Service, Boothbay Harbor, Maine.*

NEW AND RECENT RECORDS FOR FISHES IN CHESAPEAKE BAY.—Since the publication of "Fishes of Chesapeake Bay", by Samuel F. Hildebrand and William C. Schroeder (1928, Bull. U. S. Bur. Fish., 43: 1–366) at least 15 additional species have been reported or observed. This list is presented in an attempt to bring up to date our present knowledge of the fishes from the Bay. Unless otherwise specified, identifications were made by the author.

Carcharias taurus Rafinesque, sand shark. Reported from the Bay by Bigelow and Schroeder (1948, Fishes of the Western North Atlantic, 1: 105).

Cetorhinus maximus (Gunnerus), basking shark. A basking shark about 3 meters long was caught off Poquoson by Hine and Davis Furman on March 12, 1950. The young shark was identified from a newspaper photograph by L. R. Richardson of Victoria College, New Zealand, who was visiting the Laboratory at that time.

Galeocerdo cuvier (Le Sueur), tiger shark. One specimen reported by Bigelow and Schroeder (1948, *op. cit.*: 272).

Gymnura altavela (*Linnaeus*), greater butterfly ray. Two greater butterfly rays were caught by trawl 10 miles east of Back River on August 8, 1954. These measured 1220 mm. and 1300 mm. between the tips of the pectoral fins.

Aetobatus narinari (Euphrasen), spotted eagleray. Although listed by Hildebrand and Schroeder (1928, *op. cit.*: 70) it was not seen during their investigation. Bigelow and Schroeder (1953, Fishes of the Western North Atlantic, 2: 462) state that there is no recent evidence of the spotted eagleray from Chesapeake Bay. On September 26, 1956 a specimen was captured in a pound net owned by Cecil Reilly off New Point Comfort. The specimen, a male, measured 870 mm. between the tips of its pectoral fins and 510 mm. from snout to base of the tail; the tail was 1390 mm. long.

Albula vulpes Linnaeus, bonefish. A specimen caught in a pound net owned by Captain E. Crockett off Seaford in March 1948 was identified by W. A. Van Engel.

Microgadus tomcod (Walbaum), tomcod. A specimen 77 mm. in standard length was caught by trawl on May 28, 1956, five miles west of Cape Charles.

Hoplostethus mediterraneus Cuvier and Valenciennes. The report by Longley and Hildebrand (1941, Carnegie Inst., Publ. 535: 53) of this deep water fish in Chesapeake Bay may possibly have been the result of an error.

Seriola zonata (Mitchill), slender amberjack. Ginsburg (1952, Inst. Mar. Sci., 2(2): 66).

Seriola falcata Cuvier and Valenciennes, falcate amberjack. Ginsburg (1952, *op. cit.*: 60).

Seriola fasciata (Bloch), little amberjack. Ginsburg (1952, *op. cit.*: 60).

Coryphaena hippurus (Linnaeus), common dolphin. On August 19, 1955 a dolphin 44 mm. in standard length was caught by J. Dolan in Sarah Creek, five miles upriver from the mouth of the York River. This specimen was identified by Victor G. Springer of the University of Texas. A second small dolphin, 66 mm. in standard length, was

seined from Hampton Creek by Lloyd Amory on October 2, 1955.

Euthynnus alleteratus (Rafinesque), little tuna. Two, measuring 620 and 660 mm. in standard length, were obtained from a pound net owned by John King at the mouth of the York River on October 13, 1949, and identified by J. D. Andrews. Other little tuna have been seen in fall pound net catches in the lower York River in 1950, 1954, 1955 and 1956.

Microgobius thalassinus (Jordan and Gilbert), scaled goby. Reported by Ginsburg (1934, Copeia, (1): 35) who showed that *M. holmesi* and *M. eulepis* were the male and female of *M. thalassinus*.

Evorthodus lyricus Girard. Ginsburg (1935, Bull. Bur. Fish., 47: 120) indicated *Mugilostoma gobio* to be the young of *E. lyricus*.

Gobionellus boleosoma (Jordan and Gilbert), darter goby. Ten specimens were captured in a tidal creek at Broad Bay near Lynnhaven Inlet on September 29, 1954.

Prionotus scitulus scitulus Jordan and Gilbert, Atlantic slender searobin. Reported from the Bay by Ginsburg (1950, Tex. Jour. Sci., 2(4): 504).

Prionotus tribulus tribulus Cuvier and Valenciennes, Atlantic bighead searobin. Also reported by Ginsburg (1950, *op. cit.*: 518).

Hippoglossus hippoglossus Linnaeus, Atlantic halibut. Walford reported the capture of a six-foot halibut in pound nets off Reedville (1946, Copeia, (2): 100).

Remora australis (Bennett), whale sucker. This remora was caught by some children on the beach at Gloucester Point on June 21, 1954 near the Virginia Fisheries Laboratory and was identified by E. A. Lachner of the U. S. National Museum.

For reviewing the manuscript the author wishes to thank E. A. Lachner of the U. S. National Museum and J. L. McHugh of the Virginia Fisheries Laboratory.—WILLIAM H. MASSMANN, *Virginia Fisheries Laboratory, Gloucester Point, Virginia.* Contribution from the Virginia Fisheries Laboratory No. 71.

AGGREGATIONAL BEHAVIOR IN A FRESHWATER SCULPIN—The following observations were made July 25, 1956, over the narrow shoal, one to three feet deep, along the southeast shore of Karluk Lake, Kodiak Island, Alaska. The bottom was coarse gravel with a fair amount of rubble. In the early afternoon the sun was shining brightly, the water was clear and calm, and visibility to the bottom was excellent. The water temperature was approximately 55° F.

The rowboat, drifting slowly and quietly in the slight breeze, passed directly over a boulder of about one-half cubic yard volume. The upper surface of the boulder was not greater than two square feet in area, and lay at a slope of 20° from the horizontal, with the sunlight falling directly upon it.

An estimated 100 to 125 sculpins, *Cottus aleuticus* Gilbert, adults and sub-adults, were piled on top of the boulder. Over part of the area they were at least two to three fish deep. They were motionless and did not stir until the boat was almost upon them. Then in almost leisurely fashion the majority of them deserted their perch and swam a considerable distance away. Even after the boat had passed over the rock some 15 or 20 fish remained in position. Fifteen minutes later I moved the boat over the rock once more, this time propelling it against the wind by poling. The resulting commotion was enough to drive away the remaining fish.

Nowhere else in the vicinity or in the lake were sculpins observed in congregations of even a few individuals.—JOHN GREENBANK, *Olathe, Colorado.* Published by permission U. S. Fish and Wildlife Service.

EXTERNAL MORPHOLOGY OF AN EMBRYO WHALE SHARK, *RHINCODON TYPUS* SMITH.—While at the Marine Laboratory, Texas Game and Fish Commission, Rockport, Texas, during the summer of 1956, I took the opportunity of examining closely what apparently is the only extant specimen of an embryo whale shark, *Rhincodon typus*.

The events surrounding the finding of the egg case and contained embryo in 31 fathoms of water, 130 miles south of Port Isabel, Texas, June, 1953, have been described by Breuer (1954, Texas Game and Fish, Jan.: 4–5, 29). Baughman (1955, Copeia (1): 54–55) has also noted the find and supplied an excellent photograph of the specimen.

Total length of the specimen is 355 mm. The length from the tip of the snout to the deepest point of indentation of the lunate tail is 276 mm. The specimen is a male. Teeth are weakly developed.

The dimensions which follow are expressed as absolute measurements in millimeters, followed by proportions (in parentheses) as per cent of total length of the specimen preserved in formalin after three years.

Snout to first dorsal fin 132 (37.2), to second dorsal fin 194 (54.6), to caudal fin 233 (65.6), to anal fin 195 (54.6), to pectoral fin 63 (17.7), to pelvic fin 153 (43.1), to eye 18 (5.0), to first gill slit 53 (14.9), to second gill slit 60 (16.9), to third gill slit 66 (18.6), to fourth gill slit 72 (20.2), to fifth gill slit 78 (21.9).

Length of first dorsal fin (basal attachment) 35 (9.8); height 23 (6.5). Length of basal attachment of second dorsal fin 16 (4.5); height 13 (3.6). Height of dorsal lobe of caudal fin (measured from precaudal pit) 117 (32.9); ventral lobe 57 (16.0). Length of base of anal fin 15 (4.2); height 10 (3.5). Length of base of pectoral fin 30 (8.4); height

44 (12.3); anterior margin 55 (15.5); posterior margin 48 (13.5). Length of base of pelvic fin 10 (2.8); height 16 (4.5).

Horizontal diameter of eye 6 (1.7). Distance between inner margins of nostrils 34 (9.5). Breadth of mouth 44 (12.4). Height of external opening of first gill slit 24 (6.7), of second 26 (7.3), of third 26 (7.3), of fourth 24 (6.7), of fifth 23 (6.4). Distance from origin of pectoral to origin of pelvic fins 93 (29.2); origin of pelvics to origin of anal fin 43 (12.1).

Breadth of tail at base of caudal fin 14 (3.9), depth 11.5 (3.2). Breadth of belly at origin of first dorsal 50 (14.1), depth 57 (16.0). Greatest body breadth 63 (17.7) at posterior margin of pectoral fin when appressed against side. Greatest depth 62 (17.4) slightly posterior to margin of appressed pectoral. Greatest girth 200 (56.3) at belly.

Bigelow and Schroeder (1948, Fishes of the Western North Atlantic, 1: 189–190) have described the presence of two dermal ridges on each side of the body of the whale shark, the upper ridge dividing into two. Only one such ridge is evident on the embryo, and it corresponds to the upper of the two noted by Bigelow and Schroeder. On the specimen under consideration the ridge becomes distinct anteriorly at the level of gill slits 2 and 3. This ridge then divides into two at a distance of 109 mm. posterior to the snout (30.7 per cent of total length), or at a point dorsal to the posterior margin of the pectoral fin when pressed against the side.

The matter of presence or absence of oronasal grooves in relation to systematic position of the species has been considered by Regan (1906, Proc. Zool. Soc. Lond., 745), Garman (1913, Mem. Harv. Mus. Comp. Zool., *36:* 41), Barnard (1935, Ann S. Afr. Mus., *30:* 647), and Bigelow and Schroeder (*op. cit.:* 188). The whale shark embryo has a distinct furrow 6 mm. long connecting each nostril with the mouth. A flap-like continuation of the skin of the upper lip covers the furrow (Fig. 1). This structure is, of course, not the distinct open groove found in Orectolobidae (Bigelow and Schroeder, *op. cit.*, Fig. 29), but rather appears to be a specialization of that groove.

The extent to which the yolk had been absorbed, together with the relatively advanced development of structures previously described would seemingly point to the nearness of emergence of the embryo from the egg case. Thus the size at hatching should closely approximate the size of the specimen at hand. The total length of the yolk sac and stalk is 47 mm. The yolk sac alone is 24 x 22 x 12 mm. in size, the stalk being 23 mm. long and attached in the ventral midline of the shark at the level of the origin of the pectoral fins.

Appreciation is expressed to Miss Patricia Pew, Biologist, Marine Laboratory, Texas Game and Fish Commission, Rockport, for Figure 1. The

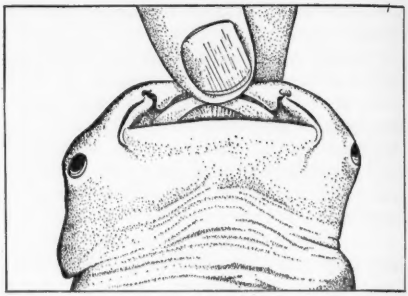

Fig. 1

specimen of the whale shark is on public exhibition at the Marine Laboratory.—GEORGE K. REID, *Department of Zoology, Rutgers University, New Brunswick, New Jersey.*

MUGIL CEPHALUS IN OKLAHOMA AND NORTHERN TEXAS.—On June 12, 1956, K. E. Sneed, V. E. Dowell and I collected 20 species and approximately 4,000 fishes from the draft tubes of the station service generators (small generators that produce the power for operation of the dam) of the Denison Dam, Lake Texoma. A single adult striped mullet (*Mugil cephalus*), 17.3 inches in total-length, was taken; it has been deposited in the University of Oklahoma Museum, Division of Zoology.

Subsequently I learned that another striped mullet had been caught by a fisherman on May 20, 1956, about 100 yards below the dam, and still another (reported in *Texas Game and Fish*, Aug., 1955: 20) on June 3, 1955. These were identified by E. W. Bonn, Aquatic Biologist of the Texas Game and Fish Commission and placed in the collection of his laboratory. One of the workmen at the dam also informed me that he had caught "the same kind of fish two or three years ago" in one of the draft tubes that was being drained for repairs. His remark that the stripes, the peculiar mouth (no other fish of comparable size in the region has a similar mouth), and the position of the fins made him realize that it was a fish he had never seen before, makes me believe that he had caught a striped mullet.

The Denison Dam impounds the Red River, the boundary between much of Oklahoma and Texas, and is located in Bryan County, Oklahoma, and Grayson County, Texas. (The power plant is at the south or Texas side of the dam.) It seems quite possible that the striped mullet has been an occasional visitor to the Red River of Texas and Oklahoma since the impoundment of Lake Texoma (or even before). The Red River now remains clear from the Denison Dam at least to the eastern borders of Oklahoma and Texas, (approximately 175

miles) and except during time of extreme drouth, a relatively large, continuous flow is maintained throughout the year. Regular collecting should produce additional specimens.—CARL D. RIGGS, *University of Oklahoma Biological Station, Lake Texoma, Willis, Oklahoma.*

THE EASTERN PACIFIC SPECIES OF *CALLIONYMUS*.—Two species of *Callionymus* have been described from the Eastern Pacific, both from off the coast of Colombia—*C. atrilabiatus* Garman and *C. garthi* Seale. The acquisition by the Natural History Museum of Stanford University of several collections of dragonets from the Gulf of California has occasioned a re-evaluation of these nominal forms. Our purposes in this paper are to show that *C. garthi* is synonymous with *C. atrilabiatus*, and to extend the known geographic range of the species from Colombia to the Gulf of California.

Callionymus atrilabiatus Garman

Callionymus atrilabiatus Garman, 1899, Mem. Mus. Comp. Zool., Harvard, 24: 122 (type locality: Lat. 3° 58′ 20″ N., Long. 81° 36′ W., and Lat. 7° 40′ N., Long. 79° 17′ 50″ W.). Fowler, 1944, Acad. Nat. Sci. Philadelphia, Monogr., 6: 519 (in check-list of eastern Pacific fishes).

Callionymus garthi Seale, 1940, Allan Hancock Pacific Expeds., 9 (1): 36, (type locality: Port Utria, Colombia). Fowler, 1944, Acad. Nat. Sci. Philadelphia, Monogr., 6: 519 (in check-list of eastern Pacific fishes).

Material examined.—CAS 5746, 1 specimen, 27.5 mm. in standard length, Port Utria, Colombia. Holotype of *C. garthi.*

SU 25249, 109.0 mm., from Albatross Sta. 3378, off Panama: Lat. 3° 58′ 20″ N., Long. 81° 36′ W. Syntype of *C. atrilabiatus* (not in the list of Stanford fish types, Böhlke, 1953, Stanford Ichthyological Bull., vol. 5).

SU 19393, 32, and ANSP 73901, 4, 31.5–84.0 mm., collected on the Templeton Crocker Expedition, 1936, of the New York Zoological Society, at Sta. 150, Gorda Banks, off the tip of Baja California (a mixed collection with several labels: 1, NYZS 25403, Sta. 150; 2, NYZS 25407, Sta. 150-D-16; 3, NYZS 25739, Sta. 150-D-26). These specimens are all from within a region bounded by the following four points: 23° 06′ N., 109° 29′ 30″ W.; 23° 07′ N., 109° 24′ W.; 23° 00′ N., 109° 28′ W.; and 23° N., 109° 30′ 30″ W. April 21–May 3, 1936; 20–120 fathoms; 4′ dredge.

SU 46431, 2, 62.5 and 71.0 mm., collected on the same expedition as the preceding, at Sta. 150-D-18, Gorda Banks: Lat. 23° 01′ N., Long. 109° 28′ 30″ W.; 60 fms.; May 3, 1936; 4′ dredge. (Formerly NYZS 25734.)

SU 46428, 21, 26.5–91.0 mm., collected on the same expedition as the preceding, but with no more specific data than Sta. 150, Gorda Banks. (Formerly NYZS 25369.)

SU 46430, 1, 52.5 mm., collected on the same expedition, its only data Gorda Banks. (Formerly NYZS 27047.)

SU 46429, 1, 27.5 mm., collected by the Eastern Pacific Zaca Expedition, 1937–1938, of the New York Zoological Society, at Sta. 224-D-1, Hannibal Bank, Panama: Lat. 7° 23′ 30″ N., Long. 82° 03′ W.; 40 fms.; March 20, 1938; 4′ dredge. (Formerly NYZS 28599.)

Discussion.—The holotype of *C. garthi* differs in several respects from Seale's description and figure. Seale stated that the type had no lateral line, but a reexamination of the specimen shows one to be present. Seale's figure indicates a dorsal count of IV-8; it was found to be IV-9. The figure also shows 15 pectoral rays, whereas 23 can be counted on the specimen. The type of *garthi* and the syntype of *atrilabiatus* differ in their pectoral counts, but both are included in the range of variation in this character exhibited by a series of the Gulf of California specimens (see Table I). Allowing for the difference in size, the two specimens seem similar; also, a comparison of the type of *garthi* with the smallest specimens from the Gulf of California and that from Hannibal Bank has failed to show differences to warrant their separation as distinct species.

The northernmost record for the species has been Garman's locality of Lat. 7° 40′ N., Long. 79° 17′ 50″ W. The Gorda Banks station at Lat. 23° 02′ N., Long. 109° 30′ 30″ W. represents, therefore, an extension of the known range of the species some 2300 miles, and another species is added to the fish fauna of the Gulf of California. The species has been taken at known depths of from 40 to 127 fathoms. The depth distribution does not appear to vary latitu-

TABLE I

Callionymus atrilabiatus: FIN RAY COUNTS OF THE TYPE OF *C. garthi*, A SYNTYPE OF *C. atrilabiatus*, 33 SPECIMENS FROM THE GULF OF CALIFORNIA AND 1 FROM HANNIBAL BANK, PANAMA

	Dorsal spines	Dorsal rays		Anal rays		Pectoral* rays			
	4	8	9	7	8	20	21	22	23
atrilabiatus, syntype	1		1		1	2			
garthi, holotype	1		1		1				1
Gulf of California specimens	33	1	32	2	31	4	38	17	7
Hannibal Bank specimen	1		1		1		1	1	

* A count was made on only one pectoral fin of the holotype of *C. garthi*. Counts were made on both fins of all other specimens.

dinally, as the two collections representing the extremes of 40 and 127 fathoms are very near each other (7° 23′ 30″ N., 82° 03′ W. and 7° 40′ N., 79° 17′ 50″ W., respectively) and at one end of the geographic range of the species.

The writers wish to thank Dr. W. I. Follett of the California Academy of Sciences for permitting them to examine the type of *Callionymus garthi*.—James Böhlke, *Academy of Natural Sciences of Philadelphia*, and Daniel M. Cohen, *Natural History Museum, Stanford University, California.*

NIGHT SHARKS, *HYPOPRION*, FROM THE GULF OF MEXICO AND THE STRAITS OF FLORIDA.—On June 23, 1956 a night shark, provisionally identified as *Hypoprion signatus* (Poey), was taken in a 70-foot semi-balloon trawl by the U. S. Fish and Wildlife Service's m/v OREGON The capture was made on OREGON station 1567, located about 50 miles east of the eastern passes of the Mississippi River Delta, while the trawl was fishing at a depth of about 250 fathoms. This shark, a 7-foot 1-inch adult male, is the first of the genus and species recorded from the Gulf of Mexico, but the night shark's depth range and habits make capture unlikely with the types of fishing gear commonly used in the area. The lack of records is thus no indication of rarity. Night sharks were the principal species sought by the small, but prosperous, deep-water hand-line fishery for sharks off the northwestern coast of Cuba before 1950. According to Cuban fishermen most of the sharks were taken at night in mid-water and at depths of approximately 100 fathoms. They have also stated, however, that these sharks could occasionally be taken in the daytime at depths of about 200 fathoms. One of us, Springer, has examined a series of 11 adult males ranging from 6 ft. 7 in. to 7 ft. 9 in. in length and 2 adult females each 7 ft. 10 in. in length taken off Bimini, Bahamas in 100 to 170 fathoms. Several adult females, all approximately 7½ ft. long and taken off Cosgrove Reef near Key West, Florida have also been examined by the same author. One of the latter specimens carried 5 male and 9 female embryos averaging 18 inches in length when it was caught on April second.

The best available description and figure of *H. signatus* (in Bigelow and Schroeder, 1948, Fishes of the Western North Atlantic, 1: 316–319, fig. 54), has been based on an immature specimen. Our adult from the northern Gulf of Mexico and our notes on the night sharks from the Florida Straits area together with the material available to Bigelow and Schroeder suggest a moderate amount of variation in proportions, as well as some change in the form of teeth and denticles, with the growth of the shark. The basal serrations of the upper jaw teeth of the adult sharks are much smaller and more numerous than in the small specimen, USNM 38508, figured by Bigelow and Schroeder. The denticles of the adults, furthermore, are closely imbricate and typically possess 5, 6, or 7 ridges in comparison with those of the small specimen where they are only partially imbricate and with 3 ridges. Examination of an embryo *H. signatus* in the collection of the National Museum corroborated the evidence of a tendency for smaller numbers of basal serrae on upper jaw teeth and smaller numbers of denticle ridges among the young.

Our adult male night shark from the northern Gulf has a proportionately smaller eye than any of the adults taken in the Florida Straits and the length of the snout is shorter, being only equal to the width of the mouth as measured in the freshly thawed (relaxed), post-frozen condition. In addition, the length of the base of the second dorsal fin of our Gulf specimen equals the length of the base of the anal, whereas the lengths of the bases of the second dorsals are approximately two-thirds the length of the anal bases in an adult male, an adult female, and in an 18 inch embryo collected from the Straits of Florida.

The original descriptions of all of the long-nosed, plain-colored species of the genus *Hypoprion* appear to be entirely inadequate. We suspect that *H. playfairii* Günther, which was described as a species with a short obtusely rounded snout and with differences from other species of *Hypoprion* both in fin shapes and color, does not properly belong in the genus. We are disturbed by the fact that our specimen from the Gulf of Mexico did not look like night sharks from the Straits of Florida, and before re-examining old notes and making comparisons we had concluded that our specimen was *H. hemiodon* Müller and Henle. The Atlantic American specimens have a tooth count, 31 to 34 rows in the upper jaw and 31 in the lower jaw, uniformly and perhaps significantly higher than that reported by Müller and Henle in their original descriptions (1841, Plagiostomen, pp 34–35) for *H. hemiodon* 29/29 or for *H. macloti* 27. Poey recognized two American species and described *signatus* (1868, Reportorio Fisico.-Nat. Cuba, p. 452, pl. 4, figs. 7–8) as well as *longirostris* (1876, An. Soc. esp. Hist. nat., 5: 198, pl. 9, figs. 8–9), from Cuban waters. Even if subsequent investigation shows that there are two Atlantic American species, a satisfactory adjustment of the nomenclature will be impractical without comparison of American specimens with specimens from other parts of the world.—Stewart Springer and John R. Thompson, *U. S. Fish and Wildlife Service, Washington, D. C., and Pascagoula, Mississippi.*

DISTRIBUTIONAL RECORDS OF FISHES IN WESTERN CANADA.—While in western

Canada in 1955 the writer collected four species of fishes worthy of special mention. The four include three cyprinids, previously unrecorded from Saskatchewan, and one catostomid. The three species of cyprinids listed were collected in the Cypress Hills region of southwestern Saskatchewan, the headwater country for the Frenchman River, a tributary of the Missouri River.

Hybognathus hankinsoni Hubbs was taken in the following localities: Cypress Lake, Frenchman River at East End, Maple Creek Reservoir near the town of Maple Creek. These records represent an extension of over 300 miles northwest of the previously known range, which includes extreme eastern Montana, northern Wyoming, western North Dakota, and southern Manitoba (Bailey, R. M., 1954, Copeia, (4): 289–291).

Chrosomus eos Cope was collected in the following localities: Cypress Lake, Belanger Creek, and in Cypress Hills Provincial Park (Lonepine Creek and Loch Leven outlet stream). This species has a discontinuous distribution in western Canada, being known from only two or three localities in Manitoba, a few localities in Alberta, and one locality in northeastern British Columbia.

Pfrille neogaea (Cope) was collected in Cypress Hills Provincial Park in Lonepine Creek and the Loch Leven outlet stream. In western Canada it is known from southeastern Manitoba and from the vicinity of Great Slave Lake, NWT.

The catostomid, *Pantosteus jordani* Evermann, has been reported from the Cypress Hills region of Saskatchewan by J. R. Dymond (1947, Royal Ontario Museum of Zoology, Misc. Pub. No. 1). The writer is unaware of any previously published reports of its occurrence in Alberta waters, from which a number of specimens were collected in the following two localities: a tributary of the Waterton River, five miles north of the boundary of Waterton Lakes National Park at No. 6 Highway, and in the north branch of the Milk River approximately eight miles east of the town of Whiskey Gap.

All specimens reported are deposited in the collections of the Royal Ontario Museum, Division of Zoology and Palaeontology.—W. B. Scott, *Royal Ontario Museum, 100 Queen's Park, Toronto 5, Canada.*

Reviews and Comments

EXPLORATION HYDROBIOLOGIQUE DU LAC TANGANYIKA (1946–1947). By Poll, M. Poissons Cichlidae. Rés. Sci., 3 (5B), 1956: 1–619, pls. i–x.—In this 1¾ inch thick "fascicule" Dr. Poll has given us all the new information that the year-long expedition in which he took part was able to collect on one of the most interesting species-flocks (or groups of species-flocks) in the world. All but seven of those previously described species that survive the test of the new material are redescribed, mostly from large samples. The total number of cichlid species known from the Tanganyika basin now stands at 133, most of them purely lacustrine and all but two peculiar to this basin.

This and the preceding fascicle on non-Cichlid fishes contain the factual matter on which Dr. Poll based his interesting essay on the history of the colonisation of L. Tanganyika and the origin of the species composing its ichthyofauna (Ann. Soc. roy. zool. Belg., *81*, 1951: 111–140). The phylogenetic conclusions expounded there are not repeated in this volume, and for synonymies and species-bibliographies the reader is referred to Poll's revision of the Tanganyika fishes (1946) which preceded the expedition. The work ends with a key for identification of the genera, and keys to the species of polytypic genera. The introduction includes an ecological classification, and there is a bathyorographical map with lake-bed contours made from the Expedition's echo-soundings.

Below 200 m. the lake harbours no aerobic life, being devoid of oxygen and rich in H_2S; there are no fishes below about 120 m. None of the Cichlidae leads an open-water pelagic life, but the long coastal belt provides a variety of habitats. Of these the benthic zone just above 120 m. was explored by the trawl for the first time, and one remarkable haul yielded seven new species.

The body of the work consists of clear, orderly accounts of the species under the headings: description, coloration, dimensions, length-weight relationship (the raw data), abundance, catch-statistics, habitat, food, reproduction, method of capture, economic importance, geographical distribution. For each species there is a list of specimens with details of locality and mode of capture; for the abundant species this may occupy several pages and may be supplemented by a table showing at a glance

the abundance at each station of a series of size-classes. All this wealth of information is presented with the well-known and enviable spaciousness of the Belgian publications.

Most of the ecological groups of Nyasan Cichlidae are paralleled in L. Tanganyika, but the specialized zooplancton-feeders ("utaka") of Nyasa are rather feebly represented by a few of the species of *Limnochromis*. Probably the abundant clupeid *Stolothrissa* takes their place in the economy of the lake, and not only their place, for unlike the utaka it exploits also the open water of the lake.

The place of the genus *Lethrinops*, which in Nyasa feeds on insect larvae and other small bottom-dwelling invertebrates, is taken by the unrelated *Callochromis*, *Xenotilapia* and others. In some *Xenotilapia* the inner pelvic rays are longer than the outer, a goby-like reversal of the usual condition, which Dr. Poll considers an adaption to demersal life. That it is not a necessary concomitant of bottom life is shown by its failure to occur in *Callochromis* (Tanganyika) and *Lethrinops* (Nyasa), but the pelvics of some Congo and West African species that live in rapids are similarly modified, and this fact may point to a fairly close relationship between *Xenotilapia* and these fishes of very different aspect.

There are numerous species of "rock-fishes", showing convergence with the Nyasan fishes that browse on the epilithic growths and associated fauna. For those familiar with the specialized dentitions of these and other genera (e.g. *Plecodus* and *Perissodus*) the revelation of the associated diets is illuminating. The voracious fishes of the genus *Lamprologus*, comprising thirty-four species in L. Tanganyika and a few in the Congo, form with *Julidochromis* and *Telmatochromis* a group with no other close relatives in the lake or elsewhere.

Dr. Poll recognizes subspeciation in five cases. In each of two pairs the division is between northern and southern basins of the lake; in a third, one subspecies is confined to Burton Gulf, the other occurs on suitable shores of the northern basin excluding this gulf. The members of the other pairs are differentiated in depth-range. In addition, *Ophthalmochromis ventralis* shows evidence of a north to south cline, or, as Dr. Poll suggests, of hybridization between two 'races'. In *Callochromis pleurospilus*, a species strictly confined to sandy shallows, each of six populations has its characteristic mean in numbers of gill-rakers, dorsal or anal rays or scales. Conceivably these populations may be small enough for the differences to be due to genetic drift, but if fluctuations in lake-level are at all like those in Nyasa it is unlikely that their differentiation is permanent.

Most of the lacustrine species, whether mid-water or bottom-dwelling, have emarginate or forked caudal fins, so resembling the lacustrine *Haplochromis* and derived genera of Nyasa, but contrasting with the species-flock of Lake Victoria, which retain the truncate tails of their relatives in rivers and swamps. In Tanganyika, however, *Lamprologus* and its related genera have truncate caudals, except in a few species of *Lamprologus*. It is tempting to suggest that *Lamprologus* may be one of the latest colonisers of the basin, from the Congo, with an evolutionary history more comparable in time to that of the Victoria species-flock than to that of most other Tanganyika genera.

In his essay of 1951 Dr. Poll emphasized the contrasting effects of the formation of the lake upon the Cichlidae on the one hand and the members of other groups—Polypteridae, Mormyridae, Siluroidea, Cyprinidae—on the other. To the Cichlidae the lake presented an opportunity to be seized, to the others a barrier to be avoided, so that we have in the lake's eastern affluent, the R. Malagarazi, a portion of the Congo fauna cut off by the lake.

The lake which divided the Malagarazi from the Congo, however, may not have been the first lake in the present basin. It may have been an extension of a lake already existing and populated south of the Malagarazi, and so would have interpolated not only an unfavourable physical environment, but a well-established fauna across the course of the river. It has still to be explained why this fish-fauna should have consisted mainly of Cichlidae.—ETHELWYNN TREWAVAS, *British Museum (Natural History), London, S.W. 7, England.*

OSTEOLOGY OF THE REPTILES. By Alfred Sherwood Romer. University of Chicago Press, 1956: xxi + 772 pp., 248 text-figs. $20.00.—"So it is out at last! No disappointment after the long waiting." These words of the late Thomas Barbour announcing the appearance of an especially anticipated piece of herpetological work in the review columns of *Copeia* are recalled to mind as an appropriate greeting for Dr. Romer's magnificent new book on reptilian osteology. For here at last is a modern account of our present knowledge of the nature and evolution of the skeleton of fossil and living reptiles prepared in the masterly style that has come to be expected of Dr. Barbour's successor as director of the Museum of Comparative Zoology at Harvard University. And no disappointment is the matchless organization and skill with which Dr. Romer has woven this synthesis from a scattered literature and his own vast experience into an integrated and coherent discussion of a complex subject. An outstanding contribution in every regard, Romer's big book will stand for a long time to come as a definitive work of classic stature. Indeed

here is a publication that must be in the library of every herpetologist deserving of the name.

It seems especially fitting that the name of Thomas Barbour should be linked to the announcement of the publication of this book, for nowhere is there a better illustration of the peculiarly significant position that "T.B." holds in the development of herpetology. Barbour, himself, made little contribution to the study of the osteology or major classification of reptiles. Yet it was in his role as patron of American herpetology that his personal wealth and enthusiasm supported the preparation and publication of the direct ancestor of Romer's book, Samuel W. Williston's *The Osteology of Reptiles* (1925, Harvard University). Williston's more or less completed manuscript had been discovered after his death in 1918 and was edited for publication by Dr. William K. Gregory. And when Williston's *Osteology* went out of print in the late 1930's, it was Thomas Barbour who urged Dr. Romer to undertake a revision. "T.B.", if he were here, would be delighted by the result.

Romer's book is no mere revision of the Williston publication, but stands as a completely new work. Although he has retained the basic organization of his predecessor, Romer has re-evaluated the mass of information accumulated since the appearance of the original *Osteology* and blended it with previously known data into a brilliant treatment of the subject. Inclusion of the most recent findings on the reptile skeleton, plus the addition of new sections and the expansion of others has produced a work over twice the length of Williston's 300 page account. Fundamentally the new *Osteology*, like the old, consists of two major portions. First there is an extensive structure-by-structure analysis of the osteology of the group (462 pages) followed by a classification of the Class Reptilia down to subfamilies based upon a synthesis of osteological characteristics (274 pages). Since the book aims at a comprehensive discussion of the osteology of all known taxa of reptiles, both living and extinct, a considerable part of the report deals with fossil forms. However, in view of the interests of the majority of the readers of *Copeia*, I will restrict the remainder of my comments and criticisms to those sections of general significance or to those which relate to the osteology of reptile groups still represented by living species.

The account opens with a summary discussion of the relationships between nonskeletal organ systems and the reptile skeleton. Although rather brief (45 pages), this chapter is one of the most interesting and informative in the book. In it Romer succinctly presents data on muscle attachment and bone shape, the principal foramina, fenestrae and fossae of the skull and postcranial skeleton and their association with specific muscles, nerves, arteries or veins. Also covered are the relations of the primary sense organs, including the parietal and pineal organs, to special structural patterns. Probably the most noteworthy feature is the discussion of the inner ear in reptiles, including a series of excellent figures and an explanation of the peculiar situation in turtles. Another short chapter concisely summarizes the nature of skeletal elements, the significance of ossification centers and presents a classification, according to embryonic development, of the elements of the reptile skeleton.

The remaining chapters of the first two-thirds of the book take up successively the skull, mandible, axial skeleton, girdles, limbs, miscellaneous skeletal parts and finally dentition. Each structure is considered first in a general way with a presentation of basic terminology. Then follows an elaborate descriptive analysis of the principal patterns found in the major reptile groups. Usually a typical or primitive type of each order or suborder is described in detail. The major variations exhibited within the taxon are then treated in a comparative manner.

The chapters on the skull are among the best in the book. Particularly outstanding is the description of the general cranial structure of reptiles. It includes not only an account of the essential elements of the reptile skull as exemplified by the primitive fossil cotylosaurs, but also a beautifully cogent analysis of the embryonic development of the braincase in living forms. Particular attention is given not only to the morphologic relations of the bones to one another but also to their relations to the brain, sense organs, cranial nerves and major blood vessels. It is to be regretted that a more extended consideration of the kinetics of the skull is not presented in this section. Comparative discussions of the skull and its evolution in the four living orders of reptiles are excellent. The parts concerned with the cranium in the Squamata, although brief, are extremely instructive. A few additional figures of varied snake skulls would have been useful, however.

The mandible receives a separate and complete chapter, although a great many lower jaws are illustrated in the sections on the skull. Each bony element found in the mandible is described and the structure of each major group is briefly covered. There is some confusion in the use of the terms: adductor fossa, Mecklian fossa, Mecklian orifice and mandibular fossa, between this portion of the book and other chapters. The obvious differences between modern familial groups of reptiles in mandible characters both with regard to number of elements and the nature of the fossae, foramina, canals and shape are superficially covered.

The axial skeleton is fully analyzed and its embryonic development, structural features and regional differentiation are discussed. Systematic

comparisons are made for each region: axis-atlas, cervical, dorsal, sacral and caudal. The ribs and sternum are treated briefly in separate sections.

The chapters on the components of the appendicular skeleton are of a uniformly high quality. The discussion of the limbs, an area of special interest to Romer, is especially thorough and the only really adequate summary of reptile appendages in print. Of great value are the general considerations of posture, limb proportions, reduction of limbs, bipedal locomotion and adaptations for aerial, arboreal, fossorial and aquatic habits.

The account of the miscellaneous skeletal elements although adequate, is perhaps the weakest portion of the book. Romer covers very nicely the structural variation of the stapes, but his remarks on the hyoid, larynx and tracheal rings, dermal armor, gastralia, turtle shells and scleral ossicles are not up to the standard of the rest of the book. Quite possibly the fact that these structures are rarely preserved as fossils has resulted in this summary treatment. This portion of the report and the sections on the sternum, however, are the only parts of the book where Romer exhibits any bias for fossil material as indicated by neglect of structures of obvious systematic significance in living groups. It would have strengthened the chapter if a larger series of representative hyoids had been illustrated. A more complete report on osteoderms would also have been an improvement. Actually it would be difficult to identify with certainty the body osteoderms of the several living orders on the basis of the presented data. The discussion of turtle shells would have been enhanced by figures of several additional forms instead of only *Testudo* and the plastron of *Stereogenys*. By way of contrast the skulls of about 30 different turtle genera are figured.

The final analytical chapter on dentition is brief (13 pages) and appears to have been added as an afterthought. A more comprehensive consideration of variation in tooth shape and number and the relationship of dentitional types to feeding habits would have improved the section. The manner of tooth replacement, a feature of great evolutionary significance in lizards, is not clearly explained nor properly emphasized. Most of the remarks relating to this matter pertain to the order of replacement of individual teeth and not to the process of replacement.

While the first section of this book will be of use to the herpetologist attempting to identify single bony elements or as a source of comparative data, it is the second part of Romer's work that will probably be of greatest interest. Here Romer sets out an entirely new classification of the Class Reptilia based upon skeletal characteristics. The results of his synthesis of available information are often surprising, always stimulating and in many instances will act as an impetus for more detailed re-analyses by other workers of the osteology of numerous reptile groups. Many of the proposed classificatory changes may seem at first glance to be radical but the evidence presented to support most of the modifications are such as to require careful consideration by any one concerned with the major classification of reptiles.

The new classification is introduced with a short review of previous classifactory systems from Owen (1860) to von Huene (1952). This account is followed by an outline of the major groups recognized in the succeeding pages, the Subclasses Anapsida, Lepidosauria, Archosauria, Ichthyopterygia, Euryapsida and Synapsida, with a listing of orders placed in each subclass. The fossil mesosaurs are not referred to a particular subclass because of their isolated position and poorly known skeleton. It is probably for this reason that Romer does not use the name Parapsida for the ichthyosaurs, although the term would be more in line with the other names adopted. The preliminary section is followed by a complete description of the salient osteological features of all major reptile taxa (down to family in most cases) presented in a phylogenetic sequence. Included as an integral part of each section is a list of all available generic names proposed within each suprageneric group and an indication of the geologic and geographic range of every valid genus. The systematic arrangement of every taxon is carefully re-evaluated and innovations are numerous.

The turtles are treated in admirable fashion, thanks no doubt in large part to consultations between Romer and Dr. Ernest E. Williams, one of the leading authorities on this order. The classification adopted recognizes three suborders of testudinates, the primitive Amphichelydia, the Cryptodira and the Pleurodira. The arrangement of living families, all members of the latter two groups, follows the scheme proposed by Williams (1950, *Bull. Amer. Mus. Nat. Hist.*, 94: 505–562) in all essentials. The peculiar Permian *Eunotosaurus* is provisionally accepted as a turtle ancestor. Romer utilizes the ordinal name Chelonia in preference to Testudinata. This seems an unfortunate choice inasmuch as *Chelonia* is a generally recognized turtle generic name.

The new classification of lizards and snakes is revolutionary and certain to cause a good deal of healthy controversy. Many of the most controversial features are centered around differences of interpretation by various workers of the nature and significance of external characteristics as compared to skeletal ones. Certain other conclusions that will evoke discussion can only be resolved by additional work on the osteology of living reptiles. Romer em-

phasizes that the skeletal features of modern reptiles are much more poorly known than the same structures in fossil groups. Thus in the sections on the Order Squamata he throws down a direct challenge to American herpetologists to undertake studies leading to a clarification of the relationships and evolution of the genera and families of recent stocks a much more significant project than the present trend toward exclusive interest in infraspecific variation and the naming of more and more subspecies. Romer's arrangement of the squamates is a noble effort to evaluate a scattered, confusing and contradictory literature. It will doubtless serve as the single most valuable basis for future work on recent groups. But, unfortunately, the skeletal characteristics of most families have been so poorly or superficially studied by neoherpetologists that almost any reasonably detailed analysis of most squamate groups must produce modifications in the definitions presented in this book. My own unpublished studies on the lizard family Xantusiidae, for example, would force the following corrections in Romer's characterization of the family. The frontals and parietals are not always paired as stated, the frontals and the parietals are fused in the genus *Cricosaura*; the postfrontal and postorbital form a single element in all recent species, they are never separate as indicated by Romer; a parietal foramen is present in some forms, not uniformly absent as stated (see Romer's figure 64 where *Xantusia vigilis* is clearly shown to have this aperture); the cheek teeth may be simple or tricodont, not always the latter; breakage septa are present in the caudal vertebrae and there is autonomy, not the opposite as stated by Romer; osteoderms are absent from the heads of most forms, Romer says they are uniformly present. Similar changes will probably be in order for most other Squamate family definitions as additional studies on their skeletons accumulate.

The lizard classification is primarily a modification and modernization of the classic arrangement of Camp (1923, Bull. Amer. Mus. Nat. Hist., 48: 289–481). Five infraorders of the Suborder Lacertilla (no mention is made of the alternate name Sauria) are recognized. The Iguania includes the families Iguanidae, Agamidae and Chameleontidae. The geckos are placed in the Nyctisauria together with the Pygopodidae. This arrangement follows recent studies that indicate that these serpentine Australian forms are essentially highly specialized geckos. The third infraorder, the Leptoglossa, is composed of the gecko-like Xantusiidae, the Teiidae, Scincidae, Lacertidae and Cordylidae. The limbless burrowing scincomorpha often regarded as distinct families (Anelytropsidae, Feyliniidae) are properly included in the Scincidae. The cordylids are removed from their sometime association with the Diploglossa and grouped with the gerrhosaurids into a single familial unit. The family Dibamidae is provisionally retained with the Leptoglossa. The Infraorder Diploglossa is arranged in most part after the recent contribution of McDowell and Bogert (1954, *Bull. Amer. Mus. Nat. Hist.*, 105: 1–142) and certain of the other radical features of Romer's lizard classification are derived from these authors. Slight differences are noted between the two systems in the position accorded the Helodermatidae and in the evaluation of the relationships of the Lanthonotidae. The amphisbaenids are placed as the distinct Infraorder Annulata.

Much more revolutionary than the revised saurian classification is Romer's reorganization of snake major taxa. Three principal subgroups of Ophidia (the term Serpentes is not mentioned) are enumerated. The first of these is the Superfamily Typhlopoidea for the blind tropical families Typhlopidae and Leptotyphlopidae. Romer does not seem to accept the McDowell and Bogert (*loc. cit.*) suggestion that the typhlopids are highly modified lizards which have evolved in parallel fashion to the snakes, although he does question the relationship of this family to the leptotyphlopids. The second superfamilial group contains the boids and their allies. Evidence is presented for the association of the presumed python *Loxocemus*, the xenopeltines, the aniliines and the uropeltines in a single family, the Aniliidae. The Boidae is broken up into four subfamilies, the Pythoninae, the Boinae, the mascarene Sanziniinae and the Erycinae for *Charina*, *Enygrus*, *Eryx* and *Lichanura*. The remaining snakes are grouped into the Superfamily Colubriodea. No attention is apparently given to the gradually accumulating evidences that the proteroglyphous snakes cannot be directly ancestral to the solenoglyphs (Haas, 1952, Proc. Zool. Soc. London, 122: 573–592), nor to the possibility that the latter group is probably directly derived from a booid stock quite independent of the colubroids. Neither does Romer consider the recent suggestions of Anthony and Guibé (1951, Comp. rend. Acad. Sci., 233: 203–204) that the proteroglyphs may be a polyphyletic group and that some of them at least are of booid ancestry. Romer considers the seasnakes to be a distinct family from the Elapidae but the pit-vipers are reduced to subfamilial status under the Viperidae.

The bulk of information on the Rhynchocephalia and Crocodilia relates to fossil forms and no detailed discussion of these groups is necessary. It is interesting to note that the crocodiles, alligators and gavials are all placed in a single family.

The book ends with an excellent bibliography of selected and partially annotated references and a comprehensive index. The printing job is excellent and an easily readable type and wide-margins add

to the overall appearance. A stout and serviceable binding is provided. The illustrations are superb and most of them have been especially prepared for this book either from actual material or previously published illustrations. The only exceptions to this general praise are some of the figures included in the final portions of the book which were taken directly from Williston and are not up to the artistic standard of the other illustrations. Errors are few, as for example *Molochus* for *Moloch* on page 407, *Elape* for *Elaphe* on page 577 and the name *Platypeltis* is utilized on figures 165 and 171, although it is placed in the synonymy of *Trionyx* on page 514.

In conclusion it can be stated again, and emphatically, that this book is a "must" for every herpetologist and is equally important for anyone interested in vertebrate morphology and evolution. In this day of rising book costs it is a pleasure to find an expensive work so well worth its high selling price.—JAY M. SAVAGE, *Department of Biology, University of Southern California, Los Angeles 7, California.*

RATTLESNAKES. THEIR HABITS, LIFE HISTORIES, AND INFLUENCE ON MANKIND. By Laurence M. Klauber. University of California Press, Berkeley and Los Angeles, 1956, in 2 volumes: volume 1, xxix + 1–708 pages, 186 figures, 39 tables, colored frontispiece; volume 27 xvii + 709–1476 pages, 57 figures, 19 tables, colored frontispiece. $17.50—A book about rattlesnakes that will stand as a classic in natural history has now appeared. It is a result of more than thirty years of observation, experiment, study, and correlation by the author, plus a synthesis of the work of many others. If there be any human knowledge about rattlesnakes, true or false, not found and considered as this treatise developed and matured, it is exceedingly well hidden.

In the preface the author states that "Certain technical material of little interest to the casual seeker for the facts of rattlesnake life has been included; but throughout, the needs of this user have been kept in view. There has been a consistent effort . . . to supply the needs of both the man who seeks some single fact to settle a bet, as well as the student with a broader purpose. In a way, this book is an encyclopedia of the rattlesnake; in it both the rattlesnake's reactions to its environment and man's reaction to the rattlesnake have been surveyed. Among other objectives, I have sought to disentangle rattlesnakes as they are from rattlesnakes as people imagine them to be." He has been faithful to these objectives.

The technical material, of interest especially to herpetologists, includes the summaries and conclusions of his researches on such topics as the systematics and geographical distribution of the species and subspecies, body form and proportions, scutellation, coloration, the rattle, growth, longevity, locomotion, and behavior. Even if the casual reader is not primarily interested in technical data, he can use these sections of the book with ease, satisfaction and profit, for no pains have been spared in his behalf. The style is clear and clean-cut, neither pedantic nor condescending; terminology is simplified, unusual words are used sparingly and, when unavoidable, adequately explained. A formal glossary, with illustrations, of specialized descriptive terms precedes the keys for identification.

In the check list, which forms an important part of Chapter 2, 65 species and subspecies are recognized, 59 in the genus *Crotalus* and 6 in *Sistrurus*. A synonymy complete enough for tracing the history of names in current use (an alphabetical synonymy is placed in a separate list) and a statement of the known geographic range are given for each. Geographic distribution of the various populations is also shown by schemes of shading and hatching on a series of ten outline maps. All but 14 of the species and subspecies are illustrated by halftone reproductions of photographs from life, mostly by Leslie C. Kobler, whose great skill is at once obvious. There are no detailed descriptions of species and subspecies.

The herpetologist interested in taxonomy and zoogeography will examine this section with care, asking if there are still taxonomic problems among the rattlesnakes, if the geographic pictures are complete. As one who has struggled with some of these problems and been frustrated by lack of material from significant areas, I think it likely that the author of the work in review has also struggled and been frustrated, especially in his study of some of the populations of small rattlesnakes of the Mexican Plateau. Doubtless he would agree that in some cases material is still inadequate, and that the accumulation of new data may result in different interpretations.

Some of the species and subspecies of rattlesnakes are difficult to identify, even for the specialist. The author has made these problems easier by preparing six regional keys, thus giving the user the advantage of eliminating at the start consideration of species and characters not needed for the task at hand, if the general locality from which the specimen came is known (e.g., east or west of the Mississippi River, mainland Mexico or Baja California). In some instances, even though actual records are absent, potential occurrence is provided for, as in the key for mainland Mexico in which three species known from nearby localities are included. The keys all reflect a happy medium between the extremes of using in the couplets bare minimal characters or long descriptive paragraphs. With the help of the

illustrations, anyone with a modicum of intelligent effort should have good success in identifications. Intergradation between subspecies, however, although noted in the statements of some of the geographic ranges and referred to casually in the chapter on Populations and Ecology, appears not to have been pointed up to users of the keys. It should be noted that intergrading specimens will not key out clearly in many cases and will continue to be puzzling. In identifying individuals representing some of the intermediate areas, even the trained zoologist—if he insists upon using a trinomial—will frequently have to make an arbitrary choice.

In addition to the keys to species and subspecies of rattlesnakes based on external characters, there are keys by Bayard H. Brattstrom to crotalid genera and to species of *Crotalus* and *Sistrurus* based on the adult skull. There are also tables of distribution by states, provinces, etc.; tables of variation in characters such as scale counts, body blotches, and counts of tooth sockets; and a tabular index to the chapter on Classification and Identification.

In the short chapter on Paleontology and Phylogeny the relatively meager data on rattlesnake fossils (mostly from the Pleistocene but some probably Pliocene) are summarized, drawing heavily on the work of Brattstrom, both published and unpublished. The author holds that the genera *Sistrurus* and *Crotalus* undoubtedly had a common ancestry on the basis of the rattle, for "it is inconceivable that so intricate a device could have evolved twice." He characterizes the prototypic rattlesnake as having a plated crown (as in *Sistrurus*, *Agkistrodon*, etc.), long tail, and small rattles; and comments that "there are strong indications that the ancestral rattler had some of the characters of the existing *Sistrurus miliarius*, although it need not have been, and probably was not, so small a snake. For the theory of the evolution of the rattle that involves the protection of the snake from being trampled by primitive hoofed animals requires a more dangerous snake than *miliarius*." The implication here is unfortunate, and probably fortuitous. In this theory of the evolution of the rattle it should not be assumed that the rattle was developed *because* of a need to warn away enemies that might trample the snake. The rattle could have started, and probably did, as an innovation in a species no larger than *Sistrurus miliarius* or *Crotalus stejnegeri*, and become advantageous as a "keep away" sound against enemies other than the hoofed mammals.

In reaching his conclusions regarding phylogenetic relationships among existing species and subspecies of rattlesnakes, the author has given special consideration "to their notable divergences from the rattlesnake mode," giving attention to the stability or plasticity of each character, and to correlations between characters. Cranial and vertebral osteology, body size, head and tail proportion, the rattle, hemipenes, lungs, venom, squamation, color and pattern, ecological preferences, and geographic range are considered significant. The majority of these characters are subsequently treated at length, especially the rattle, which is the subject of an important chapter of 67 pages. Surprisingly, however, the zoogeography of the rattlesnakes is scarcely touched upon, and the evolution of the group as it may be related to the geological and physiographical history of North America appears to have been neglected. This is all the more surprising since an historical point of view is characteristic of his treatment of nearly all the other aspects of rattlesnake biology and its relation to man.

In chapters on Bodily Functions, Behavior, Populations and Ecology, Food, Reproduction, Control and Utilization, and Enemies almost every conceivable topic in morphology and bionomics is exhaustively discussed; not only in terms of modern knowledge but also in the historical development of present-day knowledge, through the maze of fancy and fact of the earliest recorded observations. The sections on the poison apparatus, fangs and venom; the nature of the bite and the symptoms and after-effects of venom poisoning; and the treatment and prevention of snake bite should be read by everyone having either frequent or casual contacts with poisonous snakes. It should be read with extra care by zoo workers, collectors, and special students of these animals. An awareness of the habits and potentialities of venomous snakes, outdoors and indoors, may help to lessen the number of "illegitimate bites." Treatment recommended both as first-aid and for physician and hospital is based upon the best knowledge at present available, and for this reason alone the book should be in the libraries of medical men as well as naturalists.

The last three chapters deal with Indian lore, folklore, myths, and tall stories relating to rattlesnakes. The reader, once into this section, will be reluctant to lay the book down. But to say that this especially is good reading would be unfair to foregoing pages, for they too are good reading, although the different interests and aims of those who will use this book will naturally elicit different responses to its various parts.

In addition to the 243 halftone and zinc-etching reproductions which illustrate the work throughout, each volume has a frontispiece in color. An illustration of a Mexican subspecies received too late for placing in its proper sequence in Chapter 2 is inserted on page 1259. Outstanding features of the treatise as a whole are its careful documentation and indexing. The bibliography, occupying 141 pages, includes approximately 3500 titles; and the

index, covering 73 pages in double columns, includes detailed subentries under major subjects and many cross-references. Physically the book is well-made: the format and typography are in good taste, the body is printed on stock equally satisfactory for letterpress, line plates, and halftones, and the binding is in heavy gray buchram. All who have shared in the processing—copy reading, composition, engraving, proofing, press work, and binding—deserve commendation for constant maintenance of high standards of craftsmanship. Careful editing and checking of page references are also evident.

Dr. Klauber, an engineer by profession, for many years has been associated with the San Diego Gas and Electric Co. in capacities ranging from salesman to president and chairman of the board. He has long been a shining example of the gifted amateur in science, turning out some of the finest work ever done in natural history. The study of herpetology has been markedly advanced by his application of highly specialized statistical methods to problems in this field. That his interests have not been limited to rattlesnakes is shown by his many important papers on other aspects of herpetology. Unlike the traditional busy-executive who combats frustration at the dining table or on the golf course, he has used his "spare time" consistently and continuously over a period of thirty years in acquiring a vast fund of knowledge, both general and specialized—and aside from that of his main profession—out of which has come the book just described. The last word on rattlesnakes has still not been said, but it will be a hundred years or more before there will be felt a need for another summary of the natural history of rattlesnakes and rattlesnake lore.—HOWARD K. GLOYD, *Chicago Academy of Sciences, Chicago 14, Illinois*

RATTLESNAKES. THEIR HABITS, LIFE HISTORIES AND INFLUENCE ON MANKIND. By Laurence M. Klauber.—The term "colossal" applied to anything originating in California is likely to evoke a smile, but the book "Rattlesnakes" by Laurence M. Klauber is truly colossal in the best sense of the word. From the quantitative viewpoint alone the figures are most impressive—two volumes weighing over eight pounds; 1,530 pages; 238 illustrations; some 40 tables of data several of which are fold-ins of two or three pages; a bibliography of 171 pages; 72 pages of index. Qualitatively, the standard is even higher—fine quality paper; excellent reproduction of photographs; two frontispieces in full color; a large number of carefully done maps and diagrams; clear large print; handsome binding and attractive dustcovers. This encyclopedic work commands the admiration and respect not only of specialists but of all those who recognize the immense amount of careful labor that such a compilation entails. It undoubtedly stands as the most comprehensive work on a single phase of herpetology but it seems safe to say that few books in any field cover a closely specialized subject with the thoroughness, the breadth and the scope that Klauber achieves.

A simple straight-forward easy style contributes to the readability from the popular viewpoint. The volumes may be opened at almost any page, apart from the several chapters devoted to statistical data and taxonomy, and the attention will immediately be held, even for readers only mildly interested in snakes in general.

That the book has attracted wide attention in non-scientific fields is evidenced by the highly favorable reviews in such diversified magazines as *Time* and the New York Times Review of Books. This broad general interest raises the question whether the all-inclusiveness of the work may not in some degree defeat a valuable purpose that it might accomplish. A large part of the material is admirably suited as an authoritative popular natural history of the rattlesnakes but in its present form it can hardly reach the wide audience that would welcome it, if for example a condensation of the portions of the book dealing with natural history were made available, possibly as a paper-back. The author, by his style as well as by his sympathetic approach to this phase of his life-work, has an appeal for many that may never see the work as presently published.

A third portion of the present book that might command another audience with an entirely different point of view comprises the chapters dealing with the relationship of rattlesnakes and man. The author in his introductory chapter says, "Quite apart, and often quite different, from their existence as reptiles in the forest or desert, rattlesnakes have had an existence in the minds of men" and his chapters on Indians and rattlensakes, on myths and folklore, on rattlesnakes as symbols, and on other phases of the relationships with men, make up a readable story of a different character from the natural history, and the scientific portions that will serve as a reference book for the specialist.

This rare combination of scientific reference book, a popular natural history, and a study of the effect of an almost fabulous reptile on literature and society, all done in a quiet and unaffected literary style, is a monumental achievement. The author's engineering background and scientific viewpoint apart from herpetology, together with his truly amateur spirit in following an avocation that developed into a life work, have resulted in a publication of which all who are interested in any phase of reptile study may feel justly proud.—GEORGE P. MEADE, *New Orleans, Louisiana.*

CHETVERTICHNY PERIOD V SVETE BIOGEOGRAFICHESKIKH DANNYKH (THE QUATERNARY PERIOD IN THE LIGHT OF BIOGEOGRAPHICAL DATA). By G. U. Lindberg. Zoologicheskii Institut Akademiya Nauk SSSR, Moscow, 1955: 334, 38 figs., 27 tables, 1 folding map. (In Russian.)—The author has published many articles on fishes and submarine geology during the past three decades. The present work cannot well be ignored by students of submarine geology and of Pleistocene and post-Pleistocene fish distribution patterns in Eurasia and the western Pacific. A critical evaluation of the book is deferred to the various specialists who will consult it during the course of their studies. Other than part one, which is introductory, the only chapter the reviewer could appraise (Ch. 8) is an outmoded discussion of the similarities between the Siberian and Alaskan ichthyofaunas, and this may not be representative of the book as a whole. An outlined summary of the Table of Contents is given below.

After a short introduction, the subject matter is divided into thirty-three chapters which are grouped into seven parts as follows (statements in quotation marks are translated from the Russian).

"Part one. The biogeographical method of interpreting events of the recent past." Chapters 1 through 3 are included. They are concerned with a critique of current biogeographical deductions, the concept of single and grouped river systems, and the essence of the biogeographical method. Chapter 3 was previously published in 1948.

"Part two. A history of the fauna and territories of the Far Eastern seas." The author considers the history of the ichthyofaunas and territories of the PaleoAmur and PaleoHuanhe (Yellow R.) systems (Ch. 4, 5), the past history of the Pacific Ocean as revealed through biogeographical data (Ch. 6), the origin of the freshwater ichthyofauna in the basin of the Sea of Japan (Ch. 7), the history of the ichthyofauna and territory of the PaeloYukon system (Ch. 8), and an outline of the recent geological history of the Far Eastern seas (Ch. 9). Chapters 4 through 7 were previously published in 1946–1948, Chapter 8 in 1949 and 1951, and Chapter 9 in 1953.

"Part three. The problem of the origin of submarine valleys and canyons." Chapter 10 surveys the status of the problem, Chapter 11 considers hypotheses offered to explain the preservation of the microrelief of the ocean floor, Chapter 12 critically surveys hypotheses concerning the subaerial origin of submarine valleys and canyons, and in Chapter 13 Lindberg offers a biogeographical solution to the problem. Chapter 10 was first published in 1947, Chapter 11 in 1948, and Chapter 13 in 1952.

"Part four. The basis for an hypothesis of recent fluctuations in sea level which were catastrophic in time and large in scale." (During the Quaternary and even more recently, Lindberg postulates that the sea surface rose or fell to levels vastly different from today, and that each of these fluctuations took place in a very short period of time.) Chapter 14 discusses possible criticisms of the hypothesis, Chapter 15 concerns reasons for the scarcity of Quaternary marine sediments, Chapter 16 considers explanations for the discontinuous evidences of widespread marine transgressions and for their variable elevations, and Chapter 17 takes up the causes of sea level fluctuations.

"Part five. Old problems in the light of new hypotheses." In Chapter 18 Lindberg discusses interrupted distribution patterns of marine animals. Chapter 19 considers mass transmigrations of floras and faunas during the Quaternary and the probable causes of the exchanges. Chapter 20 considers the problem of how the Quaternary glaciations were brought about.

"Part six. The influence of surface glaciation and widespread marine transgressions and regressions in forming the river ichthyofaunas of Europe, Siberia, and Central Asia (faunal analysis)." Chapter 21 delimits the problem of faunal analysis. Chapters follow on the derivations of the freshwater ichthyofaunas of: western Europe (Ch. 22), the basins of the Barents, White, and Baltic seas (Ch. 23), the Black Sea basin (Ch. 24), the Caspian Sea basin (Ch. 25), Siberia (Ch. 26), and Soviet Central Asia (Ch. 27). In Chapter 28, Lindberg draws preliminary deductions from the foregoing faunal analyses.

"Part seven. The influence or effect of glaciation and eustatic sea level fluctuations on the formation of river valley territories in Europe, Siberia, and Central Asia (territorial analysis)." Chapter 29 outlines the problem of territorial analysis. Chapter 30 surveys the marine transgressions and regressions in river valley territories of Europe, Siberia, and Central Asia. The problem of correlating eustatic changes in sea level with glaciations in Russian river valleys is considered in Chapter 31. Chapter 32 traces the formation of the territories of the river basins of the Black and Caspian seas. Chapter 33 traces the development of the territories of the river basins of the western Siberian lowlands and the valleys of Central Asia.

The author's conclusions are on pages 313 through 317. This section is followed by 12 pages of literature references, a brief index to names cited in the text, and the table of contents.

Approximately 49% of the 380 titles listed in the bibliography refer to works published in languages other than Russian. About 93% of the non-Russian references antedate 1940, whereas about 48% of the Russian references were published after 1939. No

doubt this is partly a reflection of the isolation of Soviet science, imposed first by World War II and later by the creation of the Iron Curtain. In part it is also a reflection of the accelerated Soviet interest in problems of their strategically important arctic, subarctic, and Far Eastern territories and neighbors.—VLADIMIR WALTERS, *The American Museum of Natural History, New York 24, N. Y.*

EELS: A BIOLOGICAL STUDY. By Leon Bertin. Cleaver-Hume Press, London, 1956: 192, 8 pls., 55 text figs. Price, 25s.—This volume is almost entirely a translation of the second French edition of 1951; additions seem to be limited to a few new literature citations, updating of the statistical section by D. W. Tucker, and transcription of an obituary notice on the late Prof. Bertin by E. Trewavas. The book deals very largely with the European freshwater eel (*Anguilla*), and summarizes in easily digestible form the many facets of investigation that have been carried on with this fish.

THE UNDERWATER NATURALIST. By Pierre de Latil, translated from the French by Edward Fitzgerald. Houghton Mifflin, Boston, 1955: 275, 15 underwater photographs, 24 line drawings. $3.50.—The book, aside from two introductory chapters, deals with fishes found on the French coast of the Mediterranean. The bulk of the species accounts are given over to quotations from other authors, information gleaned from spearfishermen, and descriptions of local fishing methods; the underwater naturalist indicated in the title rarely appears.

THE UNDERWATER GUIDE TO MARINE LIFE. By Carleton Ray and Elgin Ciampi. A. S. Barnes, New York, 1956: 338, 16 colored plates, 194 text figures. $8.75.—Whereas de Latil's book is obviously for popular consumption, that by Ray and Ciampi belongs in the estimable British semi-popular category. Though the latter authors have tried to justify the broad title, their obvious interest is in fishes, which take up two-thirds of the book. The introduction shows a timely concern for conservation in those inshore areas that have recently become infested with spearfishermen. The first two chapters are brief summaries of recent work on oceanography, zoogeography, ecology, and animal behavior; the third deals mostly with underwater photography. Section three, taking up more than half of the book, is on the vertebrates. Interesting accounts and figures are given for at least one of most of the groups of American marine fishes. Five turtles and a sea snake are also dealt with. The coverage for the Bermuda region, where the authors are really at home, is far broader than elsewhere, and more of the accounts are at first hand. Most of the many underwater photographs by the authors are superb; considerably less can be said for the line drawings and colored figures of fishes. The book ends with an up-to-date bibliography of references for further reading. Ray and Ciampi have, in the reviewer's opinion, written with the highly commendable purpose of promoting among the public a serious interest in life under the sea and have carried through with notable success.

GUPPIES AS PETS AND SIAMESE FIGHTING FISH. By Myron Gordon. TFH Publications, Jersey City, N. J., 1955 and 1956 respectively.—Each of these brochures is of 32 pages containing numerous photographs and line drawings and sells at 35¢. Though they are intended primarily as popular guides to the care and breeding of the fishes treated, a good deal of biological, especially genetic, information of interest to scientists has been included.

THE LIFE STORY OF THE FISH. By Brian Curtis.—The English edition published by Jonathan Cape, 30 Bedford Square, London is still available although the American edition is out-of-print.

ZOOLOGICAL PHOTOGRAPHY IN PRACTICE. By Hugh B. Cott. Fountain Press, London, 1956: 370 pp. 52/6 shillings.—The emphasis upon photographing animals in their natural habitats makes this book of value to those interested in wildlife photography. Much of the text (Chapters I–VIII) is a comprehensive discussion of cameras, accessories and techniques useful for biological photography. Chapters IX–X consider the opportunities for wildlife photography in the tropical rain forest, desert and savannah, environments which pose contrasting problems to the photographer. The last chapter, a brief, annotated classification of animals, will be of little use to the professional zoologist, but should illuminate the tremendous photographic opportunities that await the wildlife photographer. Sixty-eight excellent plates illustrate techniques of photographing animals in nature.

ATLAS DES POISSONS DES CÔTES ALGÉRIENNES. Aquarelles by William Goëau-Brissonnière. Preface by René Dieuzeide. E. Imbert, Alger, 1956: col. pls. 1–72, with 2-page Introduction and 3-page list of plates, with scientific names.—This book of handsome plates has been published under the auspices of the Station Expérimental d'Aquiculture et de Pêche de Castiglione, Alger, Algeria, of which Dr. Dieuzeide is director. It supplements the "Catalogue des Poissons des côtes algériennes" that Dr. Dieuzeide published, in collaboration with M. Novelle and J. Roland in Nos. 4–6 of the new series entitled Station d'Aquiculture et de Pêche de Castiglione, from 1953 to

1955. That catalogue is a critical review, with modernized nomenclature.

ANFÍBIOS E. RÉPTEIS DO BRASIL. By Eurico Santos. F. Briguiet, Rio de Janiero, 2nd. ed., 1955: 263 pp., 65 text-figs., $6.00.—A revision of Santos' 1942 popular account, with additional figures and data. Although printed on better paper and somewhat revised the work still contains many errors and poor illustrations.

O OFIDISMO NO BRASIL. By Marcello Silva, Jr. Serviço Nacional de Educação Sanitária, Rio de Janeiro, 1956: 346 pp., 199 text-figs.—A popular account of the life and importance of Brasilian serpents. The major emphasis is on venomous species with a considerable number of distribution maps and excellent figures, many of them in color, borrowed from the works of A. do Amaral, F. da Fonesca, O. Machado, A. Prado and E. Santos, among others.

EDITORIAL NOTES AND NEWS

Common Names List (With Index)

A special reprint of "Common Names for North Aemrican Amphibians and Reptiles" (*Copeia*, 1956, No. 3, pp. 172–185) may be purchased for one dollar. Address your request to our Publications Secretary, DR. N. BAYARD GREEN, Department of Zoology, Marshall College, Huntington 1, West Virginia. All proceeds from sales of this pamphlet accrue to the treasury of the American Society of Ichthyologists and Herpetologists. Copies will prove useful to amateur herpetologists, biology teachers, museum, zoo, and aquarium curators, or to anyone interested in natural history whose main subject is not in herpetology. The index, part of the special reprint, has the common names arranged in alphabetical order for ready reference by non-herpetologists.

The Committee on Herpetological Common Names reports widespread use of the list. A complete relabeling of reptile and amphibian exhibits, to conform with the Committee's selection of names, is under way at the New York (Bronx), Philadelphia, and San Diego Zoos, and the Carnegie Museum. A similar project will be undertaken soon at the American Museum of Natural History. Publications, now in preparation or in the planning stage, that will use the list include:

Check List of North American Amphibians and Reptiles (7th ed.)—Karl P. Schmidt.

Field Guide to the Reptiles and Amphibians—Roger Conant.

Handbook of Herpetology—Coleman J. Goin.

Manual of North American Vertebrates (Reptile section)—Fred R. Cagle.

Reptiles of the World—Karl P. Schmidt and Robert F. Inger.

Revision of *Amphibians and Reptiles of Western North America*—Robert C. Stebbins.

Authors preparing articles in herpetology for submission for publication in *Copeia* are requested to make the use of common names conform with the Committee's list.

Zoological Nomenclature

Notice is given that the possible use by the International Commission on Zoological Nomenclature of its Plenary Powers is involved in applications relating to the undermentioned name included in Part 1 of Volume 13 of the *Bulletin of Zoological Nomenclature*, which will be published on 25th January 1957:

(1) ***bengalensis*** Daudin, [1802] (***Tupinambis***) and ***salvator*** Laurenti, 1768 (***Stellio***), validation of (Class Reptilia) (Z.N. (S.) 761).

The present Notice is given in pursuance of the decisions taken on the recommendation of the International Commission on Zoological Nomenclature, by the Thirteenth International Congress of Zoology, Paris, 1948 (see *Bull. zool. Nomencl.* 4: 51–56, 57–59; ibid 5: 5–13, 131).

Any specialist who may desire to comment on the foregoing application is invited to do so in writing to the Secretary to the International Commission (Address: 28 Park Village East, Regent's Park, London, N.W. 1.) prior to July 25, 1957. Every such comment should be clearly marked with the Commission's File Number (A. (n. s.) 34) and sent *in duplicate*.

If received in sufficient time before the commencement by the International Commission of voting on the application in question, comments received in response to the present Notice will be published in the *Bulletin of Zoological Nomenclature*; comments received too late to be published will be brought to the attention of the International

Commission at the time of the commencement of voting on the application in question.

Senckenberg Museum

On the invitation of the Rumanian Institute for Cultural Relations DR. R. MERTENS, Director of the Senckenberg Institute, together with DR. W. KLAUSEWITZ, Ichthyologist, made an information trip to Rumania from Aug. 28th to Sept. 20th. They visited biological institutes in Bucharest, the capital of Rumania, and made trips to the delta of the Danube, the western regions of the country and to the Institute for Marine Biology near Constanta on the Black Sea.

DR. R. MERTENS left Frankfort in January, 1957 for another five-months trip to Indonesia and Australia for ecologic-taxonomic studies. He will be accompanied by the mammalogist DR. H. FELTEN.

Literary Executor of E. R. Dunn

Before going to Colombia in 1943, DR. DUNN asked his "great and good friend" KARL P. SCHMIDT to serve as his literary executor. The specific duties were envisaged as, in the event of his death, to take charge of his library, his stock of reprints, his manuscripts and notes, and his herpetological correspondence files. DR. SCHMIDT accepted these duties as eminently proper ones, for EMMETT REID DUNN was equally his own great and good friend. Any inquiries regarding reprints should be addressed to DR. SCHMIDT at Chicago Natural History Museum, Chicago 5, Illinois.

Corrected Measurements of Terrapin Hatchlings

A recent note on reproduction and development in the northern diamondback terrapin, *Malaclemys terrapin terrapin*, (1955, Copeia, (4): 311) gave the carapace length of four hatchlings as 27.0, 27.0, 28.5, 27.0 mm. These measurements are in error, and correctly should read 32.5, 32.0, 33.5, 32.5 mm.

Fish and Wildlife Service

The reorganization of the U. S. Fish and Wildlife Service, resulting from the Congressional Fish and Wildlife Act of 1956, has now been virtually completed. Under this Act the Service is divided into a Bureau of Commercial Fisheries and a Bureau of Sport Fisheries and Wildlife, both under the Office of the Commissioner. Attached to the Commissioner's Office are the Offices of Information, of International Relations, and of Program Review. At the head of the whole Service is the newly created position of Assistant Secretary of the Interior for Fish and Wildlife.

MR. ROSS L. LEFFLER, a member of the Pennsylvania Game Commission for 28 years and for 16 years its President, has been appointed Assistant Secretary. MR. ARNIE J. SUOMELA has been appointed Commissioner. MR. DANIEL H. JANZEN, formerly a Fish and Wildlife Service Regional Director, has been named Director of the Bureau of Sport Fisheries and Wildlife, with MR. ABRAM V. TUNISON as Assistant Director for Fisheries within this same Bureau. The Director of the Bureau of Commercial Fisheries have not been officially designated.

In connection with this reorganization two "task force" committees were established to make long range plans for their respective Bureaus. The committee for Sport Fisheries and Game consists of CECIL S. WILLIAMS, chairman, LEE E. YEAGER, WILLIAM T. KRUMMES, LEWIS R. GARLICK, HARRY A. GOODWIN, DANIEL H. JANZEN, TRAVIS S. ROBERTS, LANSING A. PARKER, and EDWARD J. DOUGLASS. That for Commercial Fisheries is made up of OSCAR E. SETTE, chairman, ERNEST PREMETZ, HAROLD E. CROWTHER, DONALD L. MCKERNAN, and HARVEY L. MOORE. Both committees were to have met in early January.

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